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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1914.

GENERAL PHYSICS.

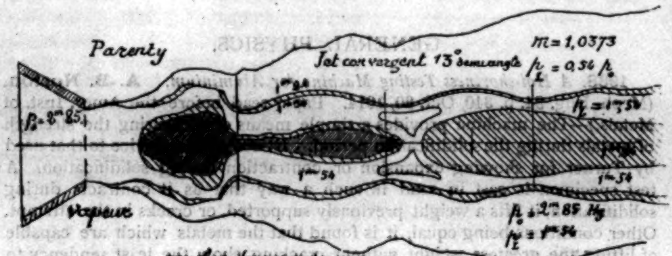
1938. *A Hot-shortness Testing Machine for Aluminium.* **A. B. Norton.** (Mech. Eng. 84. p. 840, Oct. 80, 1914. Paper read before the Amer. Inst. of Metals.)—The machine provides a simple means of measuring the strength of metals during the solidification period. It is a similar device to that used by Turner for showing expansion or contraction during solidification. A test specimen is cast in sand in such a way that as it contracts during solidification, it lifts a weight previously supported, or cracks in the attempt. Other conditions being equal, it is found that the metals which are capable of lifting the greatest weight without cracking, show the least tendency to crack in the foundry. It is found that test-pieces of Al 2 in. long and ¼ in. in diam. may raise from 25 lbs. to 225 lbs. C. O. B.

1939. *Registration of Rhythmic Hourly Time-signals.* **J. Baillaud.** (Comptes Rendus, 158. pp. 1780–1782, June 15, 1914.)—The reception of the Paris time-signals is usually made by two methods—coincidences or direct registration. A method is suggested for simplifying the latter method. By means of a special pendulum adjusted to beat at the same rate as the wireless signals, the phase is made to coincide with that of the signals, and then it only remains to connect the auxiliary pendulum with the chronograph. The precision obtainable is of the order of 1/500 sec. The adjustment for phase is by means of a second pendulum controlled by an electromagnet. C. P. B.

1940. *Determination of Difference of Longitude between Paris and Nice by Wireless Telegraphy.* **B. Jekhowsky.** (Comptes Rendus, 159. pp. 577–580, Oct. 12, 1914.)—Methods recommended by Claude, Ferrié, and Driencourt [Abstract No. 984 (1911)] have been applied to the determination of the longitude of Nice. Astronomical observations at Paris and Nice were made with the prism astrolabe. The course of the chronometers was controlled before and after the astronomical observations by pendulums. Comparisons were made at the commencement and the end of each of the series of observations, and were also effected even when there were no observations. Between the two series of astronomical observations of an evening, there was intercalated the comparison of the chronometers of Paris and Nice by radio-telegraphic signals emitted every day by the Eiffel Tower. A mean of 14 coincidences per evening were obtained with a precision of 1/100 sec. With due allowance for sources of error which are dealt with in the paper, the author concludes that the difference of longitude Paris–Nice is 0h. 19m. 51·204s. ± 0·06s. The observations relate to the period May 8–June 5, 1912. E. O. W.

1941. *The Constitution of Fluid Jets.* **H. Parenty.** (Comptes Rendus, 159. pp. 857–861, Aug. 3, 1914.)—Forms a continuation of a previous paper [see Abstract No. 1786 (1914)], and describes the results obtained by exploring the pressures at different points in jets issuing from orifices of various forms. In this way it was possible to find the form of the pressure contour-sheets in the fluid jets [see Figs.] These contour-sheets were found to suffer marked constrictions at regular intervals, forming a succession of nodes and loops along the axis, as soon as the function $R = (p_0 - p_1)/p_0$ attained its limiting value $R_L = a/m$ (where a and m are two coefficients depending respectively upon the nature of the fluid and upon the shape of the orifice). For any given orifice the form of the "limiting" jet was found to depend solely on the ratio and not on the absolute values of the pressures p_0 and p_1. J. W. T. W.

FIG. 1.



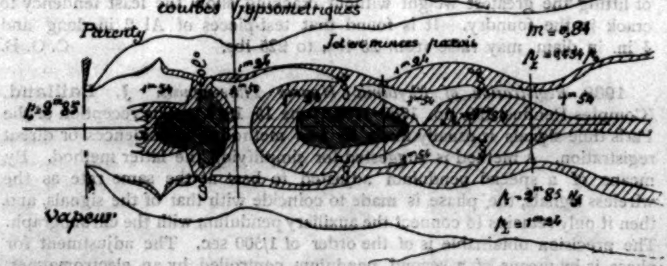


FIG. 2.

1942. *The Change of the Modulus of Elasticity and of other Properties of Metals with Temperature.* **F. C. Lea** and **O. H. Crowther.** (Engineering, 98. pp. 487–489, Oct. 16, 1914.)—Specimens of mild steel, nicro-copper and high-tension brass have been tested mechanically at temperatures up to 700° C., in a horizontal testing machine. Heating was effected by an electrical furnace, while measurements of the elastic extensions were made by means of a specially designed extensometer. In the case of the mild steel the modulus decreases slowly from about $29·5 \times 10^6$ lbs. per sq. in. at 0° C. to about $27·5 \times 10^6$ at 300° C. Above this temperature the decrease becomes more rapid, the value of the modulus at 600° being only about $12·5 \times 10^6$ lbs. per sq. in. The ultimate stress shows a maximum at 250°, at which temperature there is a minimum in the reduction-of-area curve. When the stress obtained by dividing the breaking load by the original area is greatest, however, the stress on the actual fractured area is least. Nicro-copper shows a continual and fairly constant decrease in the modulus as the temperature rises. The breaking shows a not very well marked maximum at about 150° C. An interesting point about this material is its low reduction of area at high temperatures. High-tension brass shows a continual fall in strength, and a continual rise in the ductility, with rising temperatures. F. C. A. H. L.

1943. *Filtration of Liquids through Sand or other Similar Porous Media. Analogy between Electrical and Filtration Currents.* **J. Boussinesq.** (Comptes Rendus, 159. pp. 849–854, Aug. 8, 1914.)—In a former paper (Ibid. 158. p. 1846) the author has shown that the filtration of a liquid through homogeneous sand follows the same elementary law as its uniform flow through a polished capillary tube. The present paper seeks to explain this agreement, although the irregular and sinuous free spaces between the sand fragments render difficult an explanation satisfactory in every detail. Since the absolute flow velocity is very small, acceleration may be neglected, although this may itself be eliminated by rapid changes of direction, while the force due to descent will be neutralised by friction, as in the case of a polished cylindrical tube. The author's theory assumes that after a short interval there is a common direction of translatory flow movement in each small space containing a large number of sand grains, by virtue of which the pores orientated in this direction behave as cylindrical tubes filled with flowing fluid, while those pores or interstices orientated otherwise will be filled with fluid at rest, and so constitute in conjunction with the sand particles the walls of the assumed filtration tubes. On this theory the author deduces a number of interesting relations including the analogy between the filtration and electrical currents. H. H. Ho.

1944. *Theory of the Transpiration of Gases through Porous Media.* **J. Boussinesq.** (Comptes Rendus, 159. pp. 890–894, Aug. 10, 1914.)—This paper is an extension of the author's theory [see preceding Abstract] on the filtration of liquids through sand, to the case of gases. The fundamental filtration formulæ established for liquids were $U = I/\mu$, $q = m/\mu I$, and $I = -d\phi/dn$, where U is the average speed of filtration, μ the specific constant characteristic of the particular medium employed, q the discharge per unit area from the surfaces of equal charge $\phi =$ const., m the ratio of the capacity of the active pores to the total apparent volume, and I is the force of descent along the normal dn at the particular level surface of charge $\phi =$ const. The particular modifications for the gaseous case are made, and,

after a mathematical discussion, analogous formulæ $U_e = I'\mu'$, $q_e = m/\mu'I'$, and $I' = p_e/L$ are established; where U_e is the average speed of transpiration, q_e the discharge per unit area, μ' the constant characteristic of the gas and of the porous medium, p_e the gas pressure at entering, and L is the length traversed. I′ is the quotient p_e/L and constitutes a kind of driving force.
H. H. Ho.

1945. *Approximate Evaluation of Filtration Constant μ for a Medium constituted of Spherical Grains of given Diameter.* **J. Boussinesq.** (Comptes Rendus, 159. pp. 519–525, Sept. 28, 1914.)—The present paper contains an evaluation of the filtration constant μ based upon the theory of filtration put forward in a preceding paper [see preceding Abstract]. The average speed of filtration can then be calculated for a homogeneous sand whose grains are spherical and of given diameter R. The method adopted was to divide up one of the surfaces of equal charge, supposed for example horizontal, into equilateral triangles of side 2R by three series of paralleled lines inclined at 60°. At each apex is placed a sphere of radius R. Then the whole volume is supposed filled with equal spheres by placing them in contact along the verticals to the first surface through the apices of the equilateral triangles. The order of magnitude of μ will remain the same with this simplified arrangement for facilitating the construction of rectilinear filtration tubes. The mathematical discussion on the above assumption is given in detail, and for water at 10° C. the result found is $\mu = 0{\cdot}00082/(2R)^2$. A discussion of previous work on sand filtration with reference to the grain dimensions concludes the paper.
H. H. Ho.

1946. *Resistance of a Fluid to the Horizontal Translation of a Spindle-shaped Body in the Direction of its Axis.* **Fournier.** (Comptes Rendus, 159. pp. 484–486, Sept. 7, 1914.)—Experiments by Eiffel with spherical models and every other shape suitable for aeronautics, by Fuhrmann with spindle-shaped bodies of circular section, and by Costanzi on spheres and models of dirigibles, have led to an expression for the resistance R which is encountered, namely—

$$R = w/g\,[1 - \tfrac{3}{8}M\,(\sin \pi/2\,.\,V/\Omega)^{1/4}]$$
$$\times \left\{K\Sigma V^{2-\phi}\,(1 - l^2/L^2)\,\cos \pi/2\,.\,V/\Omega + 0{\cdot}27\,BV^2(l/L)^{1{\cdot}8}\right.$$
$$\left.\times\,[0{\cdot}45\,(1 + 0{\cdot}44\,\sin 8\pi/2\,.\,V/\Omega)]^{(l/L)^3}\right\}$$

in which w is the weight in kg. of 1 m.³ of fluid, V the speed of a horizontal current in m. per sec., B the plain section of the surface Σ of length of L and principal diam. l, ϕ the constant relative to the dynamic difference introduced by frictions, K the constant of these frictions, M a coefficient characteristic of the surface Σ, and Ω is a critical speed whose remarkable property is to reduce R to an expression directly proportional to the square of the speed if the fluid is incompressible, and only transitorily so if it is elastic. The present author has investigated the case when the fluid is elastic and has verified his formulæ from the various data to hand. [*Errata* (Ibid. p. 504, Sept. 14, 1914).]
H. H. Ho.

1947. *Distribution of Pressure round Cylindrical Bodies exposed to Air Currents.* **A. P. Thurston.** (Engineering, 98. p. 257, Aug. 21, 1914.)—A hollow rod 0·882 in. in diam., having a hole 1/50 in. in diam. through one side, was tested in a wind tunnel; the inside of the rod was connected with one arm of a manometer, the other arm of which was connected with a Pitot tube exposed to the same wind current. The rod was arranged to rotate so that pressure measurements at different points on its perimeter could be measured. Wind velocities were varied from 6·2 to 27·4 miles/hour, and the pressure distribution for each velocity was plotted in polar curves which show the following general characteristics:—The compression area subtends an angle of 39° on each side of the centre line. The max. suction occurs on the up-stream side of the bar about 70° from the centre line. The shapes of the curves do not appear to vary with wind velocity. The suction is uniform over the entire down-stream side. [See also Abstract No. 1777 (1913).] **F. S. Cripps.** (Ibid. p. 301, Sept. 4, 1914.) C. A. B.

1948. *Temperature-coefficients of the Free Surface-energy of Liquids from* — *80° to 1650° C.* I. *Methods and Apparatus.* **F. M. Jaeger.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 329–365, Sept. 26, 1914.)—The method of measuring surface tension by means of capillary rise cannot be used above 400° because the walls of the capillary tubes are always damaged by the action of the molten salts. The method adopted depends on measuring the max. pressure, H, in a very small gas-bubble, slowly formed at the circular, knife-edge opening of a capillary tube immersed in the liquid perpendicular to its surface, just at the moment when the gas-bubble is about to burst. To obtain the true value of H, the readings of the manometer require to be diminished by the hydrostatic pressure, corresponding to the depth of immersion *i*. Then if the radius of the capillary tube is *r* cm., the specific gravity of the liquid *d*, and the observed max. pressure in dynes is H, the surface-energy χ, in ergs per cm.^{2}, is $\chi = r\mathrm{H}/2 - dr^2/3 - d^2r^3/2\mathrm{H}$. The last two terms of this equation are usually so small that they can be neglected in comparison with the experimental errors. Details are given of the different forms of apparatus used to apply this method over the range from − 80° to + 1650° C., and data are given for (1) water, (2) some colloidal solutions, (3) some organic liquids, and (4) some molten salts, KCl, KBr, KI, NaCl, Na_2SO_4, Na_2MoO_4, Li_2SO_4, and Li_2SiO_3. T. M. L.

1949. *Kinetic Theory of Gravitation.* **C. F. Brush.** (Amer. Journ. Sci. 38. pp. 113–123, Jan.–May, 1914.)—In this theory the ether is assumed to be endowed with vast intrinsic kinetic energy in wave-form of some sort capable of motive action in particles, atoms or molecules of matter, and propagated in every conceivable direction so that the wave energy is isotropic. The waves are supposed of such low frequency, or otherwise of such character, that they pass through all bodies without obstruction other than that concerned in gravitation. Distribution of the ether's energy is supposed to be uniform throughout the universe except as modified by the presence of matter. Atoms or particles are imagined to be continually buffeted in all directions by the ether waves, like particles of a precipitate suspended in turbulent water. Neighbouring particles follow very nearly parallel paths, hence no collisions occur. Each particle or atom of matter is regarded as a centre of activity due to its energy of translation initially derived from the ether. There is continual absorption and restitution of the ether's energy, normally equal in amount; but the ether is permanently robbed of as much of its energy as is represented by the mean kinetic energy of the particle or atom. The particle or atom thus has a field of influence extending in all directions, or casts a spherical energy shadow, so to speak, the depth or density of the shadow varying with the inverse square of the distance. The energy shadow of a body of matter is the sum of the shadows of its constituent parts. The energy shadows of two gravitating bodies interblend, so that the energy-density between them is less than elsewhere, and they are pushed toward each other by the superior energy-density, or wave pressure, on the sides turned away from each other.

Some interesting secondary phenomena are suggested by this conception of the mechanism of gravitation. One of these is that two bodies falling toward each other and so deriving energy from the ether would have the space between them slightly depleted of its usual wave energy, and so they would fall together a little faster than according to the inverse square law.

E. H. B.

1950. *Solar Radiation Intensities at Mount Weather, Va.* **H. H. Kimball.** (Monthly Weather Rev. 42. pp. 138–141, March, 1914.)—Solar radiation has been measured at different altitudes of the sun corresponding to air masses of 2·0, 2·5, 3·0 – 6·0 on about 10 days in each of the three months Jan., Feb., and March, 1914, and tabulated results are given in the paper. A remarkable break in the regular value of the intensity was found in Jan. For the first part of the month intensities were in fair agreement with the corresponding values for previous years, but on the 23rd a pronounced change occurred. A high haze was observed over Mount Weather on that day at sunrise and during the morning with air mass 2·0 the radiation intensity was only 60 % of the normal. During the afternoon the atmosphere cleared and the radiation rose to 87 %. Thereafter it continued about 15 % below normal till the 29th, on which day there was a dense low haze. Throughout Feb. and March values were again normal.

Intensity records are reproduced from a Callendar horizontal recording pyrheliometer for Jan. 23 (with high haze) and for Jan. 29 (low haze). By means of the interposition of a 4-in. screen between the sun and the grids of the pyrheliometer a record was obtained for periods of 20 minutes at certain times of the day of the radiation received from the sky alone. Although the total radiation received on the 23rd at midday was less than that measured on the 29th, the sky radiation alone was greater, and more than half the loss in direct solar radiation, due presumably to scattering by the dust particles, was made up by the increased radiation from the sky.

J. S. Di.

1951. *Observations on Ocean Temperatures in the Vicinity of Icebergs and in other parts of the Ocean.* **C. W. Waidner, H. C. Dickinson** and **J. J. Crowe.** (Bureau of Standards, Bull. 10. pp. 267–278, Feb. 20, 1914.)—This work was undertaken to obtain information on the possibility of detecting the proximity of ice from temperature records. From long experience of navigating officers the usual methods of taking temperatures in sea-water at widely separated intervals give no useful information for detecting icebergs. The experimental objective, therefore, was to obtain continuous temperature records, and, from their analysis, to ascertain whether the proximity of icebergs gives rise to definite temperature variations distinct from the accidental ones usually found in sea-water. The temperature equipment receives detailed descriptions and an elaborate set of diagrammatic records is appended. Variations in the salinity of sea-water due to dilution by ice melting are found to be so small as to be entirely masked by the accidental variations found in sea-water. The experiment of sounding the foghorn in the vicinity of a number of bergs was tried, but in no instance was an echo detected, while the effects of cannon fire in breaking up icebergs were disappointingly small, and the utility of powerful searchlights in their location surprisingly limited. Although the lookouts were provided with spy-glasses or with binoculars, it is of interest to note that the icebergs were invariably first seen with the unaided eye. Samples of ice broken from the berg by gunfire were found to contain considerable amounts of included air, which probably accounts for their white appearance. The ice was surprisingly hard and free from any definite cleavage planes. The temperature of the air furnished no evidence of value as to the proximity of a berg. In some parts of the ocean the water temperatures were practically constant to a few tenths of a degree for many hours, while in other parts, where no ice was near, the temperature variations were as great and as sudden as any observed in the neighbourhood of bergs. Having established the existence of such variations it follows that it will be very difficult, and often impossible, to draw definite conclusions as to the proximity of ice from temperature-records. The temperature records of Professor Barnes very generally show a temperature-rise as a berg is approached, and this is regarded by him as the "characteristic iceberg effect." The present authors' records do not corroborate this, and they explain these observational differences as due to variations in the effects due to bergs under different conditions—a conclusion supported by the fact of different temperature records being obtained in approaching a given berg along different courses. H. H. Ho.

1952. *Capillarity in Rocks with relation to Vulcanism.* **J. Johnston** and **L. H. Adams.** (Journ. of Geology, 22. pp. 1–15, Jan.–Feb., 1914.)—The idea that many of the phenomena of vulcanism may be produced by the percolation of surface water down to the zone of highly-heated magmas involves difficulties with regard to the mechanism by which the transference of liquid may take place. The old capillarity experiment of Daubree is often quoted as showing how capillarity may assist in the operation, but the experiment is here described and shown to have limitations, being nothing more than a particular application of the atmometer. It is thus shown that the magnitude of the possible effect under various conditions may be deduced from the laws of capillarity. Capillary forces are only effective when there is a surface of separation within the pores, and diminish steadily with rise of temperature, vanishing at the critical point of the liquid. Calculation shows that the effects possible at any considerable depth are, in comparison with the pressure due to the hydrostatic column, insignificant except in pores of such fineness that the amount of water which could flow through them is infinitesimal. It is concluded that the probabilities are against the idea of appreciable amounts of surface water being able to penetrate into the region of deep-seated and highly-heated rock masses. C. P. B.

1953. *Effect of Lightning on Reinforced Concrete and Steel Dome.* **C. D. Perrine.** (Science, 40. pp. 513–514, Oct. 9, 1914.)—Describes in detail the circumstances under which the reinforced concrete walls and steel dome (sheathed with galvanised iron) of the Observatorio Nacional at Cordoba were struck by lightning. The storm was particularly severe and its centre not over a mile S. by SE. from the Observatory. The storm travelled S. to N. and most of the discharges were between clouds and earth. A particularly severe direct stroke struck the lightning conductor on the Observatory and then the whole surface of the metal dome appeared to be covered with sparks or flashes. The lightning rod proper extends about 1 m. above the highest part of the dome and terminates in a brush of heavy wire. A copper cable, attached to the track upon which the dome revolves, connects the latter and one of the vertical I-beams embedded in the concrete for grounding the circuit. No signs of any discharge were found about the dome and a peon within felt nothing when the dome was struck. A relatively small fraction of the discharge may have been taken by a wooden derrick standing near the dome; probably the six lightning conductors on neighbouring buildings and the metal windmill and water-tank tower reduced the difference of potential somewhat. Induced currents in the lighting and power circuits at the moment of discharge were heavy enough to blow fuses in each. The author concludes that this experience was a severe test for the dome and wall construction and proved its ability to carry off the discharge without the least apparent damage. R. E. N.

1954. *Cause of Solar Heat.* **A. Véronnet.** (Comptes Rendus, 158. pp. 1649–1652, June 8, 1914.)—Approximate calculations are made to investigate to what extent the various theories of the maintenance of the sun's heat are supported when the factors obtained from actual observation are introduced. The three main theories regard the solar heat as kept up by (*a*) chemical action, (*b*) intra-atomic energy, (*c*) the work of gravitational attraction. The author finds that chemical action would only account for 2000 years of solar activity, and intra-atomic energy 170 years, both evidently quite inadequate for the known past activity. Coming then to the Helmholtz gravitational view, he finds that the energy due to contraction gives a value of several millions of years, which, being in accord with the period demanded by geological records, he accepts as being reliable. C. P. B.

1955. *Solar Halo seen in Virginia.* **A. W. Freeman.** (Science, 40. pp. 595–596, Oct. 23, 1914.)—A very brilliant solar halo, and appendages, was visible over a considerable portion of East Virginia for several hours on Nov. 2, 1913. The sketch accompanying the note shows the haloes of 22° and 46°, parhelic circle, parhelia, anthelion, and a tangent arc at the upper part of either halo. The tangent arc to the halo of 22° is prolonged to nearly 300° round the horizon. Four bright spots at intervals of 90° are marked on the inner halo. The accessory "suns" were at times almost as brilliant as the sun itself. The large circles round the horizon were distinctly marked, and persisted for hours. The anthelion, or bright spot opposite the sun, was only occasionally visible. The bows were brilliantly coloured, and could be seen until the sun was almost down. The sky was nearly clear, except for a few wisps of cloud and a thin haze which was densest over the face of the sun. A. E.

1956. *A Third-order Rainbow.* **H. W. Farwell.** (Science, 40. p. 595, Oct. 23, 1914.)—The observer, standing near a lake at Bridgeport, Conn., on Sept. 11, at 4.45 p.m., noticed a rainbow in an unusual position. The sun was, roughly speaking, 60° from the zenith. The sky in general was clear, though there were heavy clouds above the eastern horizon and very light cloud streaks between the observer and the sun, with a few fleecy clouds near the zenith. No rain had been falling, nor seemed likely to fall for hours; yet, between the observer and the sun, some 10° from the zenith, there appeared between two of the clouds a distinct rainbow, clearly seen by other persons. The bow was rather short, not over an eighth of a circumference, convex towards the sun, and showed plainly the usual rainbow colours.

The observer forgot to note the order of the colours, but thinks the red was on the convex side. The rainbow is explained as "the result of three internal reflections within suspended drops of such small size and number as to give no appearance of a cloud." The angle between emergent and incident rays after three internal reflections would be about 42°, which agrees passably with the rough estimate of 50°. Various authorities state that bows corresponding to three reflections are never seen, on account of the much more intense direct light from the sun. In this instance the light clouds between the observer and the sun may have served to diminish the intensity of the direct light sufficiently to let the bow be seen. A. E.

1957. *General Displacement of Fraunhofer Lines.* **W. H. Julius.** (Observatory, No. 475. pp. 252–257, June, 1914.)—In discussing the results obtained by Evershed at Kodaikanal, showing distortions of lines in the spectra of excentrically located sun-spots, and the general displacements of the Fraunhofer lines towards the red, which have been ascribed by other observers to the action of pressure or velocity, the author suggests that the phenomena are completely explained by the action of anomalous dispersion, and promises to discuss the matter fully in a paper to be published later. C. P. B.

1958. *Displacements of Fraunhofer Lines to Violet.* **T. Royds.** (Kodaikanal Observatory, Bull. No. 38. Nature, 93. p. 464, July 2, 1914. Abstract.) —While the majority of the metallic lines in the solar spectrum are shifted towards the red when compared with their positions in the electric arc spectrum in the laboratory, there seem to be important exceptions. In the case of lines unsymmetrically widened, there is a difference between their behaviour in the arc and sun, as compared with lines symmetrically widened, which all show displacements to the red. Tables are given showing the details of the variations. C. P. B.

1959. *Evidences of Rapid Convection in Stellar Atmospheres.* **W. W. Campbell.** (Lick Observatory, Bull. No. 257, 1914.)—Following up the view proposed by Evershed, that the displacements of the solar spectrum lines towards the red are not due to pressure but to velocity, the idea is extended to explain the anomalous radial velocities of certain stars. Thus the B stars generally exhibit velocities about 4·5 km. per sec. too great, and this may be due to violent convection currents in the atmosphere of these stars. In the highly attenuated stars with large volumes, these velocities of the atmospheric gases may be very much larger, and might conceivably give rise to the wide hazy absorption lines in many spectra of early type stars. C. P. B.

1960. *New Hydrogen Line, λ4686.* **E. B. Frost.** (Observatory, No. 475. p. 261, June, 1914.)—Measurements have been made of this line in numerous stellar spectra, the most reliable being in the spectrum of 10 Lacertæ, a fifth-magnitude star of spectral class O,5 (Harvard). From independent measures by two observers on 15 plates the resulting wave-length of the line is 4685·90. C. P. B.

1961. *Stars with Variable Radial Velocity.* **R. E. Wilson.** (Lick Observatory, Bull. No. 257, 1914.)—A list is given of five stars whose spectra show evidence of variable velocity in the line of sight, with details of magnitude, spectral class, etc. C. P. B.

LIGHT.

1962. *Determination of Relative Refringence of Mineral Grains under the Petrographic Microscope.* **F. E. Wright.** (Washington Acad. Sci., Journ. 4. pp. 389–392, Aug., 1914.)—Two standard methods are in common use by microscopists for determination of the relative refractivity of two adjacent mineral grains in the thin section, and also of a single grain and the liquid in which it is immersed; the first method is based on the phenomena produced by central illumination with a narrow pencil of incident rays, while in the second the phenomena obtained by oblique illumination are observed. But in many instances it is difficult to detect the faint differences in light intensity at the margins of the grains by means of which the differences in refractivity are recognised. By introducing certain modifications, involving both the sources of light and a new method of two-fold oblique illumination, it is possible to render the phenomena more easily visible, and thus to relieve the eye-strain and also to increase the accuracy. In place of the sodium flame ordinarily used, the following sources are substituted: mercury, helium, and either a calcium flame, or a molybdenum or tin spark. With these lights set up side by side, in conjunction with a monochromatic illuminator (or dispersion prism or suitable filters), the following spectrum lines are available: 546, 560, 578, and 588 $\mu\mu$. It is not difficult to determine between which two of these four lines the refractive indices of mineral and liquid coincide. Now the index of solids increases about 0·001 for a decrease in wave-length of 10 to 20 $\mu\mu$, while for liquids the change is about twice as great. If therefore the index of a mineral be measured for any wave-length between 546 and 588, its index for 589 (D line) can be estimated with an error under 0·001, and a liquid then prepared of this index, whereupon the estimated index of the mineral grain can be checked by immersion in the new liquid. Oblique illumination is obtained ordinarily by means of a sliding stop below the condenser. To reduce the field illumination, and thus increase the differences in relative intensity, a double stop has been found useful. This device consists essentially of two safety-razor blades mounted in horizontal positions on a vertical connecting bar, which in turn is attached to the side of the stage support of the microscope. These blades are so adjusted that as the lower blade swings into position below the condenser, the upper blade is brought to rest in the conjugate image plane above the condenser and between the objective and slide. The upper knife-edge faces the edge of the image of the lower one, and when the two edges just meet, the entire field of view is almost dark. If the upper blade be gradually moved away from the edge of the image, the phenomena due to oblique illumination from the lower stop are observed at first under reduced field illumination, the illumination gradually increasing until finally the conditions of ordinary oblique illumination are reached. The edges which appeared bright in the first case are now dark, and *vice versa.* The movable upper stop not only increases the distinctness of the ordinary phenomena of oblique illumination by reducing the field illumination, but it also enables the observer to reverse the phenomena, and study the slight differences in illumination against a dark field, for which the eye is more sensitive. The principle on which the first part of the new method is based is that first used by Foucault for testing the aberrations of a telescopic lens. A. E.

1963. *Photographic Null Method for measuring Absorption in the Ultra-violet.* **W. R. Ham, R. B. Fehr, and R. E. Bitner.** (Frank Inst., Journ. 178. pp. 299–328, Sept., 1914.)—The primary object of this investigation was to develop a photographic method whereby the absorption of ultra-violet light by various absorbing media could be determined quantitatively. The principle of the method adopted was as follows: The absorbing medium was placed in the path of a beam of light of constant intensity and an exposure was made for a given length of time. The medium was then removed and the intensity of the light reduced by a known amount. Another exposure was then made, for the same length of time as in the first case, on the adjacent portion of the plate. By making several exposures as above with different reduced intensities of the incident beam, a very close match could be obtained between two adjacent images of the same spectral line, and hence a fairly close estimate was obtained of the absorption for that particular wave-length. A concave grating apparatus was used in conjunction with a 220-volt quartz mercury lamp, which was found to operate with great constancy after 20 minutes. For reducing the intensity of the incident beam a set of square-woven wire screens was made up, giving a range of transmission of from 5 to 95%. The method as described gives coefficients of absorption easily to within 5%. To secure the best results the intensity of the transmitted beam of light and the time of exposure should be such as to give a light grey image on the photographic plate, and of course no shadows of the wires of the screens should appear on the grating. The time of exposure should be 10 secs. or more. In working with very faint lines the slit width should not be more than 0·8 mm. nor less than 0·2 mm. Results, with numerous photographs, are given for a number of different specimens of glass. A. W.

1964. *Relation of Absorbing Power and Polarisation.* **A. Boutaric.** (Le Radium, 2. pp. 74–81, March, 1914.)—Experiments were undertaken with the object of determining the relationship between the absorbing power and the polarisation of different illuminations passing through various media, such as silver chloride suspended in water, resin in alcohol, etc. The problem is related to the investigation of the transparency of the terrestrial atmosphere and the polarisation of skylight. It had previously been found that the proportion of polarised light diminishes as the absorbing power increases, [See Abstracts Nos. 1123 (1913), 407 (1914).] C. P. B.

1965. *Law of Reflection by Unpolished Substances.* **B. Fessenkoff.** (Comptes Rendus, 158. pp. 1271–1273, May 4, 1914.)—Formulæ are developed for the analysis of reflected and absorbed light at the surface of unpolished substances, the results giving parameters depending on the nature of the light and the properties of the substances. Calculations from the formulæ are given in comparison with the observations of Ångstrom on gypsum, magnesia, and magnesium carbonate, showing a very close agreement. C. P. B.

1966. *Dispersion of Ultra-violet Rays in Aqueous Saline Solutions.* **K. Lübben.** (Deutsch. Phys. Gesell., Verh. 16. 4. pp. 180–190, Feb. 28, 1914.)—Dispersion data are found for certain saline solutions, and the proper frequencies of the ions computed from these. The influence of dissociation on these proper frequencies is discussed, as are also changes in the frequencies, occasioned by thermal causes during solution and dissociation, computed on the basis of the quantum theory. A. D.

1967. *Dispersion of Ultra-violet Rays in Aqueous Saline Solutions.* **C. Lübben.** (Ann. d. Physik, 44. 7. pp. 977–1010, July 17, 1914.)—The equivalent percentage increment of refraction, $\Delta_n = 100(n - n_0)/n_0 m$, depends linearly on the electrolytic degree of dissociation; $\Delta_n = \beta_n + (A_n - B_n)i$. With the aid of the linear expression the values of the increment of refraction for the ion solution $= A_n$ and for the molecular solution $= B_n$ can be extrapolated. The relative refractive index of the ion solution, $n/n_0 = 1 + (A_n/100)$, depends on the wave-length according to the simple Ketteler-Helmholtz law with a specific vibration $n^2 = 1 + a + M_n/(\lambda^2\lambda_0^2)$. The kathion has no observable influence on the specific frequency of a solution; so that the specific wave-lengths for Cl, Br, I, F, ClO_3, and ClO_4 can be determined. Dissociation affects the calculated specific frequency in a manner traceable to the change in the number of molecules per unit of volume. Use is made of the quantum theory to compute the changes in the specific frequency due to solution of the salt and to dissociation. A. D.

1968. *Preventing Reversal in Photography.* **R. E. Crowther.** (Photographic Journ. 54. pp. 250–257; Discussion, pp. 257–260, June, 1914.)—The latent image; importance of the compound of halogen with gelatine; effect of steeping plate in a para-diamido substitution product of benzene. A. D.

1969. *Want of Uniformity in Photographic Development.* **H. Seemann.** (Zeitschr. wiss. Phot. 13. pp. 333–347, April, 1914.)—In stand development the result is greatly affected by streams of reduction products, which cling to the face of the film as they descend. Streaks are thus occasioned, and inequalities at the different levels of the plate. If the plates be horizontal or nearly so, face downwards, the products fall off; but no stand development can give faultless results. For landscape, however, the aberrations of density are ordinarily very small. Even with constant shaking it is impossible to avoid errors in uniformity and the production of hair-lines at boundaries of brightly illuminated areas. A. D.

1970. *Photographic Resolving Power of Plates.* **P. G. Nutting.** (Photographic Journ. 54. pp. 265–270, June, 1914. Communication from the Research Lab. of the Eastman Kodak Co.)—An investigation of the density gradient at the edge of an image formed by printing with a carefully prepared straight-edge. Reproduced micrographs showing the distribution of silver granules under different conditions are given. A. D.

1971. *Gradation in Photography: Measurement of Gamma.* **F. F. Renwick.** (Photographic Journ. 54. pp. 163–166; Discussion, pp. 166–167, April, 1914.)—Description of an improved wedge-screen instrument for gamma measurement. A. D.

1972. *Photographic Density Meters.* **F. F. Renwick.** (Photographic Journ. 54. pp. 167–172; Discussion, pp. 172–174, April, 1914.)—Discussion of density measurement methods, and description of an improved Ferguson bench photometer for measuring densities. A. D.

1973. *Images due to repeated Reflection within a Prism, and a New Method for determining the Angles of a Prism.* **J. M. Byvoet** and **R. Sissingh.** (Zeitschr. phys. u. chem. Unterricht, 26. pp. 81–88, 1913.)—In examining the refractive properties of a triangular prism, it is often found that, for moderate angles of incidence, three images of the collimator slit, instead of one, are seen in the telescope. One, due to external reflection at the front of the prism is a little brighter than the other two, which are evidently due to rays entering the prism and undergoing three internal reflections. Two of these internal reflections are total, which accounts for the fact that the two extra images are not much fainter than the image formed by the single external reflection, which takes place in air and is accompanied by loss of light. The author discusses the various paths which the rays may pursue inside the prism, and derives expressions for their deviation on emergence in terms of the prism angles and known quantities. These expressions enable the angles between the prism faces to be calculated with considerable accuracy from measurements of the positions of the slit images. In an example given, the prism angle is obtained to within two-tenths of a minute of arc. A. E.

1974. *Possibility of Detecting Contractions of the Order of the Fitzgerald-Lorentz Effect.* **C. Barus.** (Amer. Journ. Sci. 38. pp. 352–354, Oct., 1914.)—Describes with diagrams an interferometer apparatus which it is hoped may be found capable of detecting contractions of the order of the Fitzgerald-Lorentz effect. [See Abstract No. 1179 (1914).] E. H. B.

1975. *Photography: Simultaneous Development and Fixing.* **C. Otsuki** and **T. Sudzuki.** (Kyōto Coll. Sci. Engin., Mem. 6. pp. 25–28, March, 1914.)—After exhaustive trials, the authors find the following to work well. Solution A, water 60 c.cm., anhydrous sodium sulphite 3 gm., metoquinone 0·6 gm.; Solution B, water 40 c.cm., hyposulphite of soda 6 gm., caustic soda 0·5 gm.: for use mix 3 volumes of A and 2 volumes of B. The difficulty to be surmounted was the want of sufficient density, with the eating away of shadow details. A. D.

1976. *Photography: Distribution of Silver Granules in the Developed Image.* **O. Tugman.** (Photographic Journ. 54. pp. 270–278, June, 1914. Communication from the Research Lab. of the Eastman Kodak Co.)—An investigation of effect of light. The method employed is to cut microtome sections of exposed films and then develop; this gets rid of difficulties occasioned by the varying penetration of the developer. Microphotographs showing results are given. A. D.

1977. *Optical Properties of Yttrium Platinocyanide.* **S. Boguslawski.** (Ann. d. Physik, 44. 7. pp. 1077–1105, July 17, 1914. Abridged dissertation, Göttingen.)—Yttrium platinocyanide shows some anomalies, such as the occurrence of dark patches in all the quadrants seen in polarised light, and the deformation of the curves of equal difference of path. The author shows how these can be explained on certain assumptions regarding the optical constants of feebly absorbent substances. E. E. F.

1978. *Integration of Light from a Variable Source.* **H. S. Hatfield.** (Electrician, 73. p. 267, May 22, 1914.)—A proposal is made to combine the hydrogen voltameter with the photoelectric cells of Elster and Geitel, and thus provide a means of recording the variation in c.p.-hours of the intensity either of sunlight or diffused daylight. It is thought that the instrument could be made almost automatic, merely requiring reading say once a week and resetting, with possible attention to battery, etc. C. P. B.

1979. *Fundamental Law of the Grating.* **J. T. Howell.** (Astrophys. Journn. 39. pp. 230-242, April, 1914.)—A description is given of an investigation of the possibility of making measurements of the highest precision with diffraction gratings by the method of coincidences. Using the international standards from λ5208 to λ5484 in the second order, the third-order coincidences were determined with two gratings, one having 15,000, the other 20,000 lines per inch. It was shown that, starting with one standard line, and assuming the law of gratings, it was possible to determine the values of secondary standard lines to the requisite accuracy. C. P. B.

1980. *Non-spherical Dioptric Systems.* **Boulouch.** (Comptes Rendus, 159. pp. 43-45, July 6, 1914.)—A theoretical study of certain cases of elliptical and ovoidal mirrors. E. E. F.

1981. *Light-quanta.* **J. Ishiwara.** (Sci. Reports, Tôhoku Univ., Sendai, Vol. 1. No. 2. pp. 67-104, 1912.)—A mathematical discussion of the quantum theory, which, after an introduction as to the theoretical and experimental bases, treats (i) stationary radiation in free space and in solids, and (ii) general electromagnetic and optical phenomena. [See Abstracts Nos. 1458 (1908) and 1578 (1909).] E. H. B.

1982. *Replacing Photographic Plates by Gelatino-bromide Papers in Radiography.* **C. H. Vaillant.** (Comptes Rendus, 159. pp. 498-499, Sept. 14, 1914.)—Gelatino-bromide papers are only one-thirtieth the weight of plates, cost only one-third as much, and are not fragile. The times of exposure are less rapid than with plates, so that it becomes necessary to use a reinforcing screen. The following are some of the exposures required with the paper used :—

Hand, foot..............	4 secs.	Leg	10 secs.
Wrist	6 „	Shoulder and knee ...	15 „
Elbow, instep	8 „	Thorax	30 „

The coil used gives a 25-cm. spark. The detail of the photographs depends chiefly on the reinforcing screen employed. The developing bath which has been found to give the best results is made up as follows: Water, 1000; sodium sulphite (cryst.), 60; potassium carbonate, 60; hydroquinone, 15; potassium bromide, 1. A. E. G.

1983. *Spark Spectrum of Nickel under Moderate Pressures.* **E. G. Bilham.** (Roy. Soc., Phil. Trans. 214. pp. 359-371, Oct. 9, 1914.)—Solar wave-lengths are in general slightly greater than terrestrial, and this discrepancy has been attributed to the pressure of the solar reversing layer. Accordingly the effect on the nickel spark spectrum of pressures of 6 and 11 atmos., which are comparable to the pressures estimated for the solar layers, are here investigated. The pressure-chamber, method of excitation, and spectrograph employed are minutely described, together with the design and manipulating of the measuring apparatus. Burns's values for the iron arc spectrum are used as standard lines, and the measurements attain a max. accuracy of 0·002 Å.U. The region investigated lies between λλ3446 and 4593, and the detailed measurements are supplemented by reproduction of the spectrograms. The results may be summarised as follows :—The lines exhibit a remarkable variety of behaviour and may be divided into five classes according to their types of reversal or broadening. With increase of pressure the enhanced lines decrease in intensity and broaden symmetrically, while gas lines disappear. All lines are displaced towards the red, and the general effect on the relative intensities of the lines is similar to that of including self-induction in a spark circuit. For symmetrical and unsymmetrically reversed lines the average shifts are the same, but unreversed lines show larger shifts, and of these latter the lines which broaden unsymmetrically towards the red suffer the largest shifts. Certain abnormalities indicate the existence of enhanced lines at λλ8614·14 and 8608·98 (approx.), which almost coincide with two lines of the arc spectrum. C. S. G.

1984. *Spectrum of the Oscillatory Discharge in Various Gases.* **R. Brunetti.** (N. Cimento, 7. Ser. 6. pp. 890–410, June, 1914.)—The author has investigated the spectra of the oscillatory discharge passing between magnesium electrodes in hydrogen, oxygen, nitrogen, and CO_2. The first part of the discharge shows lines of the gas and of the metal of high and low excitation; in the second part the metallic lines of low excitation remain and are accompanied by the bands of the gas and of the compounds of the latter with the metal. The bands start from the positive electrode and cease at a distance from the negative one, whilst the gas lines traverse the whole space between the electrodes, and the metal lines are not found in the regions bordering on the electrodes. The first phase of the oscillatory discharge presents, indeed, those complex phenomena known as a spark; it opens the path by ionising the gas, carries with it occasional particles of the metal and heats the electrodes to redness, being then replaced by the second phase of the discharge, namely the arc. In the latter there is a localisation of the seat of emission of the various series of lines, the principal series originating in a stratum surrounding the accessory series emitted by the central regions. The heating of the electrodes during this second part of the discharge depends on the thermal conductivity of the surrounding medium; in hydrogen, the heating does not last so long as in nitrogen, oxygen, or CO_2, whilst the discharge is extinguished sooner. The sudden change in potential at the electrodes falls off in the adjacent regions; for equal magnitudes of the auto-induction, the difference of potential at the electrode is greater in oxygen than in nitrogen, and is least in hydrogen. The luminous emission is subjected to the action of the gas in which the discharge takes place, since the gas modifies to some extent both the distribution of the electric field interposed between the electrodes and also the temperature of the medium. T. H. P.

1985. *The Stark-Lo Surdo Phenomenon.* **A. Garbasso.** (N. Cimento, 7. Ser. 6. pp. 854–856, June, 1914.)—In his earlier work on this phenomenon [see Abstract No. 667 (1914)] the author has calculated the distance apart of the external components, parallel to the field, but he is unable to find any explanation of the internal components, normal to the field. Bohr's theory, in its present form, does not appear to lend itself to calculation of the latter phenomenon, which, contrary to the statements of Stark and Lo Surdo, does not turn on the Zeeman-effect. In very intense fields, the various lines of one and the same series are decomposed according to different laws. These intense electric fields are readily obtainable by the use of narrow tubes, as suggested by Lo Surdo, and the author describes the exact experimental conditions which he has found most suitable. With a tube 1·5 mm. in diam., a p.d. of about 8000 volts and a current of 1 milliamp., the first kathodic layer is reduced in length to about 2 mm. The mean fall is thus approximately 40,000 volts per cm., and it is shown that, immediately in front of the kathode, the field is about 80,000 volts per cm. The effect may then be observed by means of a single-prism spectroscope. In order to avoid damage to the tube it is necessary to cut off the current occasionally. Further, the tube may be immersed in liquid air, the low temperature being without effect on the phenomenon. T. H. P.

1986. *Band Spectra of Carbon in Magnetic Field.* **H. Deslandres** and **V. Burson.** (Comptes Rendus, 158. pp. 1851–1857, June 22, 1914.)—Until the application of large dispersion and extra strong magnetic fields was made, it was thought that band spectra were not affected by the magnetic field. With the advent of more powerful apparatus, however, it was found that various changes were introduced into the structure of the bands [see Abstracts Nos. 1489 (1913); 668 (1914)]. The present paper deals with the action of a field of 20,000 gauss and upwards, and a powerful spectrograph of three prisms giving a very long spectrum. The effects are somewhat complicated, and drawings are given to illustrate the variations described. It is hoped to devise means for increasing the field still further. [See Abstract No. 2010 (1914).] C. P. B.

1987. *Fluorescence of Gases excited by Ultra Schumann Waves.* **R. W. Wood** and **G. A. Hemsalech.** (Phil. Mag. 27. pp. 899–908, May, 1914. Phys. Zeitschr. 15. pp. 572–578, June 1, 1914.)—The experiments described are in continuation of previous work by Wood [Abstract No. 120 (1911)]. A small hole is drilled through copper and condenser-sparks are discharged against the under side, at the perforated spot. The region above the plate is photographed, and it is found that the air above the hole emits ultra-violet light, excited by radiations of some kind which come from the spark. The luminosity has the form of a narrow vertical jet and by photographing through a quartz prism a spectrum is obtained showing the so-called "water band" of the oxy-hydrogen flame and the ultra-violet bands of nitrogen. A thin fluorite plate (1 mm.) placed over the perforated spot reduces the intensity of the radiations responsible for the excitation of the water band to about 5 % of their original value. This circumstance makes it seem extremely probable that ultra-violet waves much shorter than Schumann waves are being dealt with, since the latter pass readily through fluorite. Very remarkable effects are obtained with movable and stationary gases: some gases showing a much more brilliant fluorescence when moving across the jet of rays from the spark, others responding vigorously to the excitation when quite stagnant, but showing no luminosity when in motion. In the case of air it appears as though a given mass must be acted upon by the radiations from a number of successive sparks to attain its full luminosity. This appears to be true, however, for the water bands only. For the nitrogen bands the reverse is true: they are brighter if the gas is in motion. If a current of nitrogen is directed across the spark jet, the water-band streamer is interrupted and a strong patch of luminosity appears, displaced on the spectrum. Interesting effects were obtained with CO_2, hydrogen, and iodine. E. M.

1988. *Spectrum of X-rays obtained by means of Lamellar or Fibrous Substances.* **S. Nishikawa.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 296–298, May, 1914.)—It was previously shown [see Abstract No. 85 (1914)] that the interference patterns, obtained when X-rays are passed through fibrous or lamellar substances, can be explained by assuming that the substances consist of a number of elementary crystals in certain definite arrangements. In de Broglie's experiments [Abstract No. 248 (1914)] the analyser of the X-rays was a crystal which was kept rotating. In the present instance the X-ray spectra were obtained by using fibrous substances which were kept stationary. Since the fibrous substance consists of a number of elementary crystals of a definite prismatic structure and arranged parallel to the fibre (though in other respects they were quite irregularly situated), it will play the same rôle as a rotating crystal in analysing the X-rays. The spectra so far obtained by this method are, however, too faint for close examination.

A lamellar substance such as boric acid was used quite successfully as an X-ray analyser—a photograph of the spectrum of a beam of rays from an ordinary focus tube with Pt antikathode, is given. This photograph shows that the positions of the lines in the spectrum agree more or less with those of other investigators. A value is deduced for the distance between successive (001) planes of BO_3H_3. This is found to be $8 \cdot 15 \times 10^{-8}$ cm. Observations were also made with a tantalum antikathode. E. A. O.

1989. *Asymmetric Diffraction and Re-diffraction of X-radiation.* **I. G. Rankin** and **W. F. D. Chambers.** (Nature, 94. p. 116, Oct. 1, 1914.)—Further work on this subject [see Abstract No. 1841 (1914)] has shown that for any one position of the bulb and object, the angle of diffraction is constant. This angle varies, however, with the distance of the object from the source in accordance with a simple inverse sine law ($d \sin \theta = 7 \cdot 5$ cm.) over a wide range, 8° to 40° and 50 to 10 cm. A survey of the hemisphere of X-rays emanating from the antikathode of an ordinary bulb, by taking diffraction images of a lead disc placed at right angles to the rays, shows that there is an "optimum" or axis of symmetry lying in the plane of the kathode rays and the normal to the antikathode; the axis of symmetry making an angle of 80° with the normal to the antikathode. Around this axis the effects are increasingly asymmetric. The positions of max. intensity, as determined both by photographic and electroscopic methods, are always found to be directed to the optimum axis. It has further been ascertained that the diffracted rays are almost entirely re-diffracted by a second edge. The re-diffraction occurs in two directions, *i.e.* within and without the shadow. Moreover, these effects are again definitely asymmetric when other than the optimum rays are used. E. A. O.

1990. *Radium Emanation in the Atmosphere.* **J. R. Wright** and **O. F. Smith.** (Nature, 98. p. 569, July 80, 1914.)—Working in Manilla and on Mount Pauai at an altitude of 2460 m., the authors found by the charcoal method [Satterly, Abstract No. 1445 (1910)] that the average amounts of emanation present during the 8 months of observation in terms of its radium equivalent were 82×10^{-18} gm. at sea-level and 19×10^{-18} gm. (per litre ?) on the mountain. In both cases the ratio of the greatest to the least amount observed was 4 to 1, and the changes were closely related to the weather. Fair weather gave high, and heavy rain low content, especially low during typhoons. The observations are being continued. E. M.

HEAT.

1991. *Thermal and Electrical Conductivities of some of the Rarer Metals and Alloys.* **T. Barratt.** (Phys. Soc., Proc. 26. pp. 347–370; Discussion, p. 371, Aug., 1914.)—The author has developed a new method of measuring the thermal conductivities of metals which has the advantage that it can be used for the rarer metals, since rods of about 1 mm. cross-section only are required The method, which is of the stationary temperature type, offers the further advantage that it is unnecessary to measure the temperature gradient in the rod. The quantities which have to be measured in addition to the dimensions of the rod are: the heat, H, supplied at the hot end, the difference in temperature, V, between the hot end and the enclosure, and the loss of heat, h, per cm.^{2} of the surface for unit temperature excess. It is shown that if the length of the rod is appreciable in comparison with the cross-section, the conductivity $k = \mathrm{H}^2/pqh\mathrm{V}^2$, where p is the perimeter and q the area of cross-section. Experimental details and the method of working out the results are given, and it is shown that the thermal conductivity of non-metals can also be determined in the same way. In order to test the electron theory of metals for the specimens examined the electrical conductivities, K, have also been measured and the values of k/KT tabulated, T being the absolute temperature. The values tend towards a common value 2·5 although with several metals, notably tungsten, rhodium, and iridium, there are considerable discrepancies.

F. J. H.

1992. *Melting-points of some Refractory Oxides.* **C. W. Kanolt.** (Bureau of Standards, Bull. 10. pp. 295–313, Feb. 20, 1914.)—The Arsem vacuum furnace previously used [see Abstract No. 330B (1913)] was slightly modified, and arrangements were made to sweep out the smoke from the heated oxides which affects the optical pyrometer readings. The materials as a rule are charged into the ring space between an outer and an inner tube; some gas (hydrogen, nitrogen, etc.), is passed down the inner tube, into which the pyrometer is sighted. The tubes are made of graphite or of tungsten, the latter being moulded in graphite. The pyrometer lamps were standardised with the aid of the melting-points (determined in graphite crucibles) of: Antimony, 630°; copper-silver eutectic, 779°; silver, 960·5°; copper, 1083°; diopside, 1391° C. These observations were checked by the determination of the melting-point of platinum (1 to 3 gm., as in the case of the oxides) in tubes made of a mixture of alumina and magnesia (from the Berlin Porzellan-Manufaktur) heated in a vertical aluminium furnace; heating and cooling curves were taken as for the oxides. Magnesia does not form a carbide, but is reduced by carbon at high temperatures, especially when fused; hence cooling curves could not be obtained in the graphite crucibles mentioned. The gas used for sweeping was a mixture of nitrogen and carbon monoxide; the melting-point found, 2800° C., is much higher than the values of Hempel (2250°) and most others; Ruff observed melting above 2500°, and Greenwood used magnesia crucibles up to 2500° C. Lime was melted in a tubular tungsten crucible; the tungsten melted as soon as the lime melted, probably because it had been contaminated with carbon in the mould; hydrogen was used for sweeping; the melting-point of lime found is 2572° C. (Hempel 1900°, Ruff over 2450° C.). Alumina was melted in crucibles both of carbon (the carbide formation is slow) and of tungsten, in vacuum and atmospheric pressure; the resulting melting-points ranged from 2041° to 2055°, mean 2050° C. (agreeing with Saunders, whose extreme was 2100; Hempel 1800°, Ruff 2010° C.). Chromium oxide Cr_2O_3 was melted in graphite (slow reduction on melting) and in tungsten (into which the oxide soaked); melting-point found 1990° C., Ruff gave 2060° or 2080° C. as doubtful melting-point as there was reduction. [Author's Corrigendum: The melting-point of Pt (given as 1775°) should read 1755°.] H. B.

1993. *Convection Constants of small Platinum Wires with Applications to Hot-wire Anemometry.* **L. V. King.** (Roy. Soc., Phil. Trans. 24. pp. 373–432, Nov. 12, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 563–570, Sept. 7, 1914. Abstract.)—The paper is divided into three portions. The first deals mathematically with the problem of the convection of heat from small cylinders in a stream of fluid. In the second part the laws of the convection of heat from small Pt-wires heated by an electric current over a wide range of temperature, air velocity and diameter are studied and the convection constants of these wires obtained; these are compared with the theoretical results. Part III is a description of a special type of portable hot-wire anemometer designed by the author and termed a "linear anemometer" in contra-distinction to the several forms of integrating instruments already described. The advantages of the new type are enumerated; these include the suitability of the instrument as a means of attacking such problems as the analysis of velocities in the neighbourhood of rapidly revolving aeroplane propeller blades, or between the blades of centrifugal fans. F. J. H.

1994. *Influence of Pressure upon Forced Thermal Convection of Platinum Wires.* **A. E. Kennelly** and **H. S. Sanborn.** (Amer. Phil. Soc., Proc. 53. pp. 55–77, Jan.–May, 1914.)—Experiments have been carried out in continuation of work already published [see Abstract No. 144B (1910)] with the object of testing the effect of air pressure upon forced convection from heated wires maintained at a constant temperature. The experimental wire was held in a fork rotated by means of an electric motor so that the wire moved in a direction perpendicular to its length. The results show that for pressures between 0·5 and 8 atmos. the rate at which heat is dissipated varies not only as the square root of the speed of the wire as already found but also approximately as the square root of the air pressure in accordance with the theoretical result of Boussinesq. Departures exceeding observational errors were found outside the above limits of pressure, which may have been caused by the production of eddy currents arising from the smallness of the tank used. The effect of moisture in the air upon the forced convection seems to be small but has not been fully investigated. It is shown that a thin vertical Pt-wire about 25 cm. long can, after being calibrated as above, serve as an anemometer. The record of wind velocity requires, however, to be corrected for both the temperature and the pressure of the air. The degree of precision is greatest at low wind-velocities. F. J. H.

1995. *Melting-points of the Refractory Elements.* I. *Elements of Atomic Weight from* 48 *to* 59. **G. K. Burgess** and **R. G. Waltenberg.** (Bureau of Standards, Bull. 10. pp. 48–59, 1914.)—The melting-points in pure hydrogen of the metals of the iron group, viz., Ni, Co, Fe, Mn, Cr, also Va and Ti are determined chiefly by means of the micropyrometer [see Abstract No. 621 (1913)] which is shown to be an instrument of precision for the determination of the melting-points of refractory metals and salts. In the cases of the metals examined the effect of the alloying of microscopical particles with the Pt or Ir heating strip is found to be inconsequential until after melting, the melting-points determined for Ni, Co, and Fe being the same as those found for considerable quantities heated in crucibles of magnesia in an electric furnace, the temperature of which was determined by means of a Holborn-Kurlbaum form of Morse pyrometer. For the micropyrometer determinations a calibration curve of the form $\log C = a + b \log T$ is assumed for the pyrometer lamps—where C is the heating current and T the absolute temperature—the melting-points of Ni (1452°), Pd (1549°), and Pt (1755°) being used for the calibration. In the cases of Cr, Mn, Va, strictly pure materials were not available, so that estimates for the pure substances are made from observations from the impure. The most probable melting-points of the pure metals are included in the following table—

Metal.	Ni.	Co.	Fe.	Mn.	Cr.	Va.	Ti.
Purity	99·83	99·95	99·98 ±·01	97–98	98–99	97–98	99·9
Probable melting-point..................	1452 ± 3	1478 ± 5	1530 ± 1	1260 ± 20	1520 to>Fe	1720 ± 30	1795 ± 15

Photomicrographs illustrating several points mentioned in the paper are given. These were taken from the cold strips after the melting-point determinations had been made. F. J. H.

1996. *Mechanical Equivalent of Heat.* **G. Guglielmo.** (Accad. Lincei, Atti, 23. pp. 698–708, May 8, 1914.)—It is illogical to apply Poisson's law and the first principle of thermodynamics to the determination of the ratio of the specific heats of a gas by the method of Clément and Desormes. The author indicates a method which is free from criticism on the ground of a *petitio principii.* E. E. F.

1997. *Inflammability of Mixtures of Methane with different Gases.* **F. Leprince-Ringuet.** (Comptes Rendus, 158. pp. 1999–2001, June 29, 1914.)—The experiments concern the lower and upper limits of the inflammability in mixtures of methane with oxygen, air, and carbon dioxide. When the ratio CH_4/O_2 is plotted as ordinate against the N_2/O_2 ratio (or the CO_2/O_2 ratio) as abscissa, two very similar curves are obtained, both nearly symmetrical with regard to the ordinate 0·5, the abscissæ in the latter case being 0·56 of those in the former case. Thus a mixture containing several incombustible gases behaves sensibly as if each incombustible element were replaced in a definite ratio by another of these gases. In other words, the curves are the same, but displaced in the direction of the abscissa. Hence the knowledge of one curve permits of predicting the inflammability of mixtures with other incombustible gases. H. B.

1998. *Vapour Pressures of Silver, Gold and Bismuth Amalgams.* **E. D. Eastman and J. H. Hildebrand.** (Amer. Chem. Soc., Journ. 36. pp. 2020–2030, Oct., 1914.)—In continuation of the work on zinc amalgams [see Abstract No. 1554 (1913)] measurements have now been made of the vapour pressures of amalgams of Ag, Au, and Bi at about 318°. Owing to the slight solubility of silver in mercury at this tempreature, only one measurement was made with an amalgam containing 1·27 % of Ag, with which Raoult's law was found to be obeyed within the limits of experimental error. Measurements with gold amalgams at concentrations up to 23·7 % of Au showed the separation of a solid phase at a concentration of about 16·5 %. In the more dilute amalgams the vapour pressures are greater than those calculated from Raoult's law, the assumption of a rather complex gold molecule being necessary to explain the deviations. The observed results correspond well with the equation—

$$\frac{P}{P_0} = \frac{N}{N+1} \times 10^{\frac{0·23}{(1+0·25N)^2}},$$

which is similar in form to one derived by van Laar but has empirical constants.

Bismuth amalgams of all concentrations are liquid at 318° and also give vapour pressures higher than those calculated from Raoult's law. If the validity of this law be assumed, the deviations from its simple form could be explained by assuming the two equilibria :—

$$2Bi \rightleftarrows Bi_2 \text{ and } Bi_2 + Hg \rightleftarrows Bi_2Hg\,;$$

this would lead to an equation containing but two constants but of complicated form. Van Laar's equation, which permits deviations from Raoult's law without the assumption of association or other chemical changes expresses the observations very accurately in the following form :—

$$\frac{P}{P_0} = \frac{N}{N+1} \times 10^{\frac{0·1425}{(1+0·234N)^2}},$$

but too much stress should not be laid on this agreement owing to the entirely empirical nature of the constants. In order to decide between the two methods of explaining the deviations from Raoult's law, recourse must be had to other means for distinguishing between normal and associated liquids.

T. H. P.

1999. *Measurements of Isotherms of Hydrogen at 20° and 15·5°.* **P. Kohnstamm** and **K. W. Walstra.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 203–216, Sept. 26, 1914.)—Unsuccessful attempts have been made to redetermine Amagat's air isotherms, since on a measuring tube being filled with air in the manner previously described [see Abstract No. 891 (1914)] and then left for some hours at high pressure (above 1500 atmos.), the mercury suffered contamination and the glass tube and Pt contacts became coated with a black deposit. Consequently measurements were made with hydrogen and detailed descriptions are given of the methods of purifying the gas, introducing the latter into the apparatus, measuring the volume, pressure, and temperature, correcting the results, etc. The pressures were measured by means of pressure balances, the values obtained being accurate to 1 in 10,000 for low pressures and to 1 in 2000 for pressures of 1200 to 2400 atmos. Tables are given showing the pressures and volumes and the values of their product, *pv*, at 15·5° and 20°. T. H. P.

2000. *Hydrogen Isotherms of 20° C. and 15·5° C. between* 1 *and* 2200 *Atmospheres.* **K. W. Walstra.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 217–224, Sept. 26, 1914.)—The results of the pressure-volume measurements of hydrogen at 20° for pressures below 1000 atmos. [see preceding Abstract] have been calculated by means of empirical equations containing four virial coefficients, $PV = a + bD + cD^2 + dD^4$, by which they can be expressed with a high degree of accuracy. For pressures of 8 to 60 atmos., Schalkwijk gave the equation $PV = 1·07258 + 0·0006671D + 0·000000998D^2$, and the author finds that Schalkwijk's results and those of Kohnstamm and Walstra (*loc. cit.*) are covered by the expression, $PV = 1{\cdot}07258 + 0{\cdot}0_{3}6768D + 0{\cdot}0_{6}88215D^{2} + 0{\cdot}0_{11}66954D^{4} - 0{\cdot}0_{18}151D^{6}$, which represents the whole region of the isotherm below 1000 atmos. The agreement with Schalkwijk is perfect up to $D = 100$, corresponding with $P = 115$ atmos. On the other hand, extrapolation as far as ± 120 atmos. may be effected by Schalkwijk's equation, which, however, gives an error of 0·8 % at $D = 200$ or $P = 250$ atmos.; for higher densities, up to $D = 500$, the number of virial coefficients in the expression must be at least four, but it is not permissible merely to add a fourth coefficient to Schalkwijk's equation, since the deviations are sometimes positive and sometimes negative.

The data obtained at 15·5° cannot be brought into accord with those of Amagat. T. H. P.

2001. *Isothermals of Monatomic Substances and their Binary Mixtures.* XVI. *New Determination of the Vapour Pressures of Solid Argon down to —205°.* **C. A. Crommelin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 275–277, Sept. 26, 1914. Communication No. 140*a* from the Phys. Lab., Leiden.)—Doubt having arisen as to the values previously obtained for the vapour pressure of solid argon at the lowest temperatures [see Abstract No. 272 (1914)], these measurements have been repeated and the values at —206·04° and —179·62° corrected; the temperatures were measured by means of a gold-resistance thermometer previously compared with a standard Pt-thermometer, since below —200° gold is preferable to Pt for this purpose. The extent to which the observations deviate from the Rankine-Bose formula, from Nernst's formula, $\log p_{\text{coex.}} = A/T + BT + D \log T + C$, and from the formula deduced by Sackur from Nernst's heat theorem, namely, $\log p = -\lambda/2{\cdot}3RT + c_p \log T/R - 1/2{\cdot}3R \int_0^T c\,dT/T + C + c_p/2{\cdot}3R$, are shown. The heat of sublimation of argon in cals. per gm., calculated by means of the simplified Clapeyron-Clausius formula, varies from 47·36 at —189·64° to 44·51 at —205·32°. T. H. P.

2002. *Velocities of Flame in Mixtures of Methane and Air.* **A. Parker** and **A. V. Rhead.** (Chem. Soc., Journ. 105. pp. 2150–2158, Sept., 1914.)—The authors have measured the velocity of flame in a number of mixtures of methane and air in tubes of different materials. Thin strips of Wood's alloy were stretched across the middle of the tube at different points, and were fused by the passage of the flame, the exact time of fusion being indicated electrically. When mixtures of methane and air are fired from an open to a closed end of a tube, the propagation of the flame generally occurs in three distinct periods. In the first of these the flame travels with a constant and uniform velocity, whilst the second period consists of vibratory movements and a sudden increase in the velocity; in the third, corresponding with the approach of the flame to the closed end of the tube, the velocity falls to a uniform value. In tubes of a given diam. the initial velocity of explosion varies with the material of the tube, and is low with materials having a high conductivity for heat. The max. initial velocity is exhibited by a mixture containing 10 % of methane and amounts to about 70 cm. per sec. in tubes of approximately 2·6 cm. in diam. The velocity diminishes with change of the methane-content of the mixture from 10 %, and tends towards zero for 4·5 or 13·1 % of methane. The effect of a bend in the explosion tube varies considerably with the configuration of the bend and with the percentage composition of the gaseous mixture. T. H. P.

2003. *Experimental Modification of van der Waals' Equation.* **J. P. Dalton.** (Roy. Soc. South Africa, Trans. 4. Part 2. pp. 123–136, 1914.)—The complete table of saturation constants derived by the author from van der Waals' equation $(\pi + 3/\omega^2)(3\,\omega - 1) = 8\vartheta$ ... (1) [see Abstracts Nos. 1021, 1023, and 1032 (1907)] showed that this equation gives an excellent qualitative indication of the nature of the results to be expected under given conditions, but completely fails to give reliable quantitative estimates. The author hence makes an attempt to modify the equation experimentally, and tests the modified equation against such data as are accessible. Following Kuenen (" Die Zustandsgleichung," p. 123, 1907), he regards, as a first approximation, the a of van der Waals' equation of state as a function only of T and b as independent of T. Application of well-known thermodynamic relationships to the equation $(p + a/v^2)(v - b) = \mathrm{RT}$...(2) gives $a - \mathrm{T}da/d\mathrm{T} = v_1v_2(\mathrm{T}dp_s/d\mathrm{T} - p_s)$ ...(3), where p_s is the vapour pressure at temperatures T, and v_1 and v_2 are the specific volumes of the respective phases of the complex on the same isothermal. Integration between any two temperatures gives—

$$\left(\frac{a}{\mathrm{T}}\right)_1 - \left(\frac{a}{\mathrm{T}}\right)_2 = \int^{\mathrm{T}_2} \frac{v_1v_2}{\mathrm{T}^2}\left(\mathrm{T}\frac{dp_s}{d\mathrm{T}} - p_s\right)d\mathrm{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

From Young's saturation data for isopentane (Phys. Soc., Proc. 13. p. 602, 1895) the integrand of (4) was calculated. The results show that log a is a linear function of T, so that $a = \epsilon^{\alpha - \beta\mathrm{T}}$, which, with a view to the applicability of the law of corresponding states to the modified equation, may be written, $a = a_k . \epsilon^{\beta\mathrm{T}_k(1-\vartheta)}$. Equation (2) now takes the form—

$$\left(p + \frac{a_k . \epsilon^{\beta\mathrm{T}_k(1-\vartheta)}}{v^2}\right)(v - b) = \mathrm{RT}.$$

If the law of corresponding states is to hold good, $\beta\mathrm{T}_k$ should be the same for all substances, but it probably varies more or less with the complexity of the molecule. Taking its value as unity, the last equation becomes $(\pi + 3/\omega^2 . \epsilon^{1-\vartheta})(3\omega - 1) = 8\vartheta$. This equation gives a much closer quantitative estimate of the reduced vapour pressures for isopentane and methyl alcohol than does the unmodified equation, and is in good agreement with the van der Waals empirical vapour-pressure law, log $\pi = f(1 - 1/\vartheta)$, so long as the temperature is not too low; the value of f at the critical point, 3·04, is not far from the corresponding values for such typically normal substances as CO_2, 2·97, and isopentane, 2·95.

The improvement effected in the author's modified equation is further rendered manifest by using the new constants for calculating the latent heat at different temperatures, the values thus obtained for isopentane showing closer concordance with the experimental figures. In his earlier work (*loc. cit.*) the author made use of van der Waals' equation to investigate the behaviour of the specific heat of saturated vapours as a function of the limiting value of the ratio of their specific heats, an attempt being made to obtain an experimental curve, for purposes of comparison, from the isopentane isothermals under a certain assumption regarding the behaviour of the specific heat at constant volume. The objection has been raised that this assumption is not in accord with the law of corresponding states, so that it has now been abandoned. The specific heats are first deduced from the modified equation, and an experimental curve is then derived from the isopentane isothermals, the Kamerlingh Onnes equation of state being used for determining the change of C_v with the volume. Various conclusions are drawn, but the paucity of experimental data renders it impossible to test their quantitative value. T. H. P.

2004. *New Relation between the Critical Quantities: Unity of all Substances in their Thermal Behaviour.* **J. J. van Laar.** (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 451–465, Sept. 26, 1914.)—The author brings his discussion of this subject to an end [compare Abstracts Nos. 1284 and 1558 (1914)], the principal conclusions arrived at being as follows: Within a wide range, the magnitude a of the van der Waals equation of state appears not to depend on the density, so that the molecular attraction may be represented by a/v^2, for both the gaseous and the liquid condition. The independence or the reverse of a on the temperature cannot yet be decided. The magnitude b depends on both v and T, its dependence on v being expressed by $[(b-b_0)/(b_g-b_0)]^n = 1-(x/x_0)^n$, where $x=(b-b_0):(v-v_0)$ and n depends on γ which is related to $b_g : b_0$. From this it would seem that possibly the variability of b is mainly a real change, caused by the pressure $p+a/v^2$ and the temperature acting in a manner analogous to that which van der Waals had in mind when drawing up his "equation of state of the molecule," which closely resembles the above expression. Further, this agreement is remarkable with regard to the dependence on the temperature, expressed by $(b_g-b_0)/b_0 = 2\gamma'-1 = 0{\cdot}04\sqrt{\mathrm{T}}$. But, whereas van der Waals' two exponents n are different, the author's two exponents are the same and dependent on γ, that is, on T, so that n may vary from 8·2 (for $\gamma=1$) to ∞ (for $\gamma=0{\cdot}5$, *i.e.* $\mathrm{T}=0$). The change in b need not be attributed to quasi-association, since it can be well explained as the result of other influences. The fact that b_g gradually decreases with fall of temperature, so that it would coincide with b_0 at $\mathrm{T}=0$ and the variability of b would have quite disappeared—in consequence of which the ideal equation of state with constant b is the more nearly approached with the absolute zero—points to the invalidity of the kinetic assumption that for a very large volume (b_g refers only to large volumes), *i.e.* in the ideal gaseous state, b_g would equal $4b_0$. For, as deduced kinetically, b_g would still be equal to $4b_0$ at the lowest temperatures, whereas the author shows that b_g approaches more and more closely to b_0 at low temperatures. The reason of the inaccuracy of the earlier kinetic assumption, that $b_g=4m$, will be referred to in a subsequent paper.

It seems that, in principle, the whole thermal behaviour of a substance does not depend solely on the two magnitudes a and b, which determine the critical quantities, the latter in their turn governing the law of corresponding states. Every substance passes through the different types characterised by the variable ratio $b_g : b_0$—from the type of the "ordinary" substances where $b_g : b_0 =$ about 1·8 ($\gamma = 0{\cdot}9$) to that of the "ideal" substances where $b_g = b_0$ ($\gamma=0{\cdot}5$)—in the descent from ordinary temperatures to the absolute zero. The individuality of different substances, which they maintain also within the region of the law of corresponding states, is therefore determined entirely by the real height of the absolute temperature. Thus, at 323° abs. ($\mathrm{T}=10\mathrm{T}_k$), hydrogen will exhibit, on the whole, the same behaviour as helium at 52° abs. ($\mathrm{T}=10\mathrm{T}_k$), but the former has a value of about 1·7 for the ratio $b_g : b_0$ and the latter a value of about 1·2 at these corresponding temperatures. For $v_k : b_k$, the value is about 2·7 for hydrogen and helium at their critical temperatures, whilst the value of this ratio for an ordinary substance is 2·1. T. H. P.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

2005. *Electron Theory of Moving Bodies.* **J. Ishiwara.** (Sci. Reports, Tôhoku Univ., Sendai, 3. 2. pp. 65–100, March, 1914.)—A treatise on this subject which is developed from the basis of: (1) The properties of electrons and the electronic constitution of matter; (2) the field of the electron; (3) the principle of least action; and (4) the principle of relativity. [See Abstract No. 1572 (1914).] E. H. B.

2006. *Atmospheric Electricity Observations made at Kew Observatory.* **G. Dobson.** (Phys. Soc., Proc. 26. pp. 334–346; Discussion, p. 346, Aug., 1914.)—The paper gives an account of some observations on the conductivity made with the Ebert apparatus and with that devised by C. T. R. Wilson. The latter is designed to measure the current which flows into a small test-plate exposed to the earth's field and kept at zero potential. The potential gradient above the test-plate can also be determined by measurement of the charge induced upon it when freely exposed, and thus the conductivity may be deduced. With the Ebert apparatus measurements can be made of the conductivity due to positive ions, λ_+, and of that due to negative ions, λ_-. Thus the total conductivity $\lambda (= \lambda_+ + \lambda_-)$ may be obtained. Some question has been raised as to whether the conductivity as deduced from the Wilson readings is most closely allied to λ_+ or to λ, and the experiments here recorded were carried out largely to determine this question. Wilson's apparatus is commonly used on a stand with the test-plate raised some feet above the ground, and comparative readings were first taken with the instrument (*a*) in this position, and (*b*) connected to a large test-plate at ground-level. These measurements showed the conductivity as determined by the ground-level plate to be 20 per cent. higher than that determined by the ordinary method. This difference was found not to be due to any difference in the number of ions at the two levels. Evidence is put forward to show that it must rather be regarded as instrumental, the upper-level reading being adversely affected by the smallness of the test-plate and the raised position. Finally the correct or ground-level reading from the Wilson apparatus is found to agree more closely with the total conductivity of the Ebert than with λ_+ alone. J. S. Di.

DISCHARGE AND OSCILLATIONS.

2007. *Canal Rays.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 545–566, June 15, 1914.)—The author drew attention to certain types of canal rays that are obtained with kathodes of special construction, *e.g.* with a triangular kathode there are 3 bundles of canal rays from the middle points of the sides [Abstract No. 2252 (1902)]. These rays start from one side and cut across the plane of the kathode before emerging into the gas space, or they commence their course by going inwards. In the present paper it is shown that there are bundles of rays which commence by going outwards. These rays can be made bright by using a double kathode, one plate being behind the other. These latter rays are named F rays, the former C rays. When circular kathodes are used, naturally there is a uniform aureole round them. When part of the kathode is cut away in the form of a segment an F bundle is obtained from the centre of the chord going in a radial direction. A C bundle appears from the circular edge diametrically opposite, being in alignment with the F bundle. If segments are cut away on two or more chords, one F and one C bundle is obtained for each chord, the alignment still being preserved. This alignment is, however, not an essential, for if two chords intersect so that the segments cut away have a common part, the corresponding F and C bundles are not in line (see Fig.). If a dent is made in the edge of the circular electrode, this dent having a circular outline, an F bundle emerges radially from it, and a C bundle diametrically opposite. For a number of such dents, one F and one C bundle is obtained for each. The symmetrical nature of the dent is even not necessary, for if the dents are made in the form of slits the F bundles are still radial and in line with the corresponding C bundles. So it would seem that it is the chord of the slit or dent which accounts for the F bundle. This conclusion is shown to be unsound, for if a small hole of any shape is made in the electrode near the edge, F and C bundles are still obtained and still in alignment. Further proof that alignment is not a general case is given by the use of elliptical kathodes with various kinds of dents and slits. It is next proved that the C bundles, or those going inwards over the kathode, are necessary for the production of the F bundles. This is done by surrounding the kathode by a metal band at places where the C bundles ought to emerge, when the F bundles vanish. The following explanation of the F bundle is given: The rays which proceed inwards over the kathode ionise the space between the two plates. The positive ions are then set in motion by the electric field. When the form of the kathode is such that the rays proceeding inwards converge in a focus there will be a large ionisation at this point, and from it a bright bundle of F rays can emerge. If the kathode is circular, naturally these F rays will emerge from the whole perimeter. When some part of the circumference is nearer the focus than others, the rays will all emerge from this part, the reason for this being that the gas space near a kathode, and especially that between a double kathode, is positively charged, and the line of least resistance for the F bundle is that of shortest length. J. R.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2008. *Thermoelectric Measurements, especially for Calorimetry.* **W. P. White.** (Amer. Chem. Soc., Journ. 36. pp. 1856–1868, and pp. 1868–1885, Sept., 1914.)—These two papers describe a type of auxiliary installation for thermo-elements, suitable for high-temperature measurement and other work of moderate precision, and also capable of the very high precision often desired for calorimetry. With a thermo-element having nearly the same temperature at its two ends the *relative* precision required in the electrical measurement falls to a value no greater than that desired in the temperature reading, and the most serious errors ordinarily affecting the electrical thermometer practically disappear. The *absolute* electrical precision required is also comparatively low. With a convenient and easily made copper-constantan multiple thermo-element of 24 couples 0·0001 deg. corresponds to 0·1 microvolt. Two special electrical instruments are required for the attainment of a precision of 0·1 microvolt: first, an arrangement for eliminating the effect of parasitic thermal e.m.f.'s for which a common copper knife switch will serve; secondly, a potentiometer reliable to 0·1 microvolt. *Split-circuit* potentiometers are satisfactory, and also *combination* potentiometers which have two otherwise separate very simple instruments in series in the same galvanometer circuit. The potentiometer system is especially suitable for simultaneous measurements of different and differently varying e.m.f.'s. The power to take the last two figures of any reading directly from the galvanometer can be easily obtained with the thermo-element-potentiometer system, and its use is often desirable for high-temperature measurements. J. J. S.

2009. *Rheostat for Large Currents.* **R. G. Van Name.** (Amer. Journ. Sci. 38. pp. 349–351, Oct., 1914. Electrician, 74. p. 289, Dec. 4, 1914.)—This variable resistance, capable of carrying 100 amps. or more, consists of a graphite plate ¼ in. thick, having a radial piece about 2 in. wide, from which extends a curved portion forming about three-quarters of the circumference of a circle 6 in. in diam. and ¼ in. wide. The circumferential part dips in mercury contained in a copper trough. By rotation of the graphite plate about its central axis, the current has to pass through more or less of the long thin circumferential portion or through the short broad radial portion only. The whole may be kept cool by a stream of water. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

2010. *Intense Magnetic Field.* **H. Deslandres** and **A. Perot.** (Comptes Rendus, 159. pp. 438–443, Aug. 24, 1914.)—Two additional forms of electromagnet are described, in which the field is obtained chiefly by means of a very large current circulating round an insulated strip of high-conductivity metal cooled by a liquid [see Abstracts Nos. 752 and 1136 (1914)]. For several reasons, water was substituted for cooled petroleum as a cooling agent, and silver ribbon for copper. The second of these new forms of apparatus gave a field of 49,900 gauss with a current of 5000 amps. (340 kw.), no iron being employed. The first form gave a field of 48,600 gauss with 6000 amps. (570 kw.); with an iron core and a current of 5000 amps. the field obtained was 68,700 gauss. Diagrams of the two new forms are given.

G. E. A.

2011. *Lunar Diurnal Variation of the Earth's Magnetism at Pavlovsk and Pola.* **S. Chapman.** (Roy. Soc., Phil. Trans. 214. pp. 295–317, Sept. 26, 1914.)—The present paper contains an account of the methods and results of an investigation into the lunar diurnal magnetic variations at the observatories of Pavlovsk and Pola (1897–1903), and is part of a larger undertaking by which it is hoped to obtain the necessary data for the discussion of the lunar diurnal magnetic variations over the whole earth, using the method of the Gaussian potential in a manner similar to that in which Schuster applied it to the solar diurnal magnetic variations. The reduction of the observations to the required form is too great a labour for a single person to undertake, and the author hopes that directors of magnetic observatories will carry out the reductions for their own stations. For this purpose he has indicated what appears to be the simplest and most suitable computation method for the purpose, and also some of the lines along which the discussion of the results from a single observatory should proceed. For a general review of the subject see the author's previous paper [Abstract No. 350 (1914)].

The magnetic elements undergo regular variations with the period of a lunar day as in the course of a solar day, although the latter variations are much the larger. The lunar diurnal changes are the simpler in character, taking the form, when averaged over a whole lunation, of a purely semi-diurnal wave. If, however, the variation is computed from a number of days all at the same lunar phase (*i.e.* when there is a definite angular distance between the sun and moon), the solar diurnal variation having first been eliminated from the observations, harmonic components of other frequencies in the lunar day are found to be present. The investigation of these suggests a solar action modifying a regular semi-diurnal lunar variation. This action has been given in terms of a particular theory, viz., as due to a variation, periodic in a solar day, of the electrical conductivity of the medium in which flow the currents to whose magnetic potential is attributed the variable field put in evidence by the observations. The dependence of the electrical conductivity upon solar time is accounted for on the assumption that all or part of this conductivity is due to some ionising influence from the sun, and fits in naturally with a view that the lunar magnetic variations arise from the lunar tide in the earth's atmosphere in the same way as, according to Schuster's well-known theory, the solar diurnal magnetic changes arise from the ordinary daily atmospheric motions which are indicated by the barometer. The period 1897–1903 comprises 7 years during the sun-spot minimum immediately preceding the present one, *i.e.* a period of magnetically "quiet" years, and was chosen to minimise the irregular deviations of the magnetic needle which have to be averaged out in determining the lunar diurnal variations. Pavlovsk and Pola were selected because they each publish hourly values of the magnetic elements, and their latitudes render them suitable for the main purpose of this work. The chief point of novelty and importance in the present investigation lies in the use of the harmonic components of the lunar magnetic variation of frequencies other than 2, as well as the main semi-diurnal component. The second harmonic is generally the greatest, though the first (which comes usually next in magnitude) sometimes equals or even exceeds it. The fourth harmonic is generally the smallest of all. The first three are as a rule much greater in summer than in the other seasons, but a remarkable feature is that the fourth harmonic is always greatest at the equinoxes. The fact that the fourth harmonic is appreciable at all, indicates that the diurnal variation in the atmospheric electrical conductivity cannot be represented by a simple diurnal wave $a + b \cos t$, but that terms of higher frequency in the solar day must be present.

Numerous tables and calculations are included in the paper. H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2012. *Ordinals of the Elements.* **J. R. Rydberg.** (Phil. Mag. 28. pp. 144–149, July, 1914.)—Moseley having discovered a simple relation between some of the lines of high-frequency spectra and the ordinals of the elements (He = 2, Al = 13, Cl = 17, etc.), the author has calculated Moseley's series of lines more completely and in a somewhat different way. He uses the formula $10^8/\lambda = \nu = 109675a^2(N - C)^2$, where the ordinal number N varies by one unit from one element to the next. In all six series the values of N — C (and consequently C) approach very closely to whole or half units. Assuming them to end in ·0 or ·5, the spectrum lines are recalculated. There is a good agreement as regards the L-lines. The author calculates the constants *c* and *a* or *b* of the series by taking the best values of the most constant parts.

E. E. F.

2013. *Atomic Weight of Copper by Electrolysis.* **A. G. Shrimpton.** (Phys. Soc., Proc. 26. pp. 292–312; Discussion, pp. 312–318, Aug., 1914.)—In order to determine the atomic weight of copper, the relative quantities of Cu and Ag deposited by the same current have been measured. Four copper cells, separating two silver cells, were run in series, the areas of the Cu kathodes varying from 10 to 50 cm.². By plotting the actual weights of the deposits against the corresponding kathode surfaces and extrapolating to zero kathode surface the effect of kathodic dissolution was eliminated, the weight of the deposit thus being corrected for under experimental conditions. Cylindrical cells with stationary and rotating kathodes were used. For the production of a uniform coherent deposit of pure metal it was found necessary to keep the kathodic current density below a certain limiting value. This value was determined in a series of preliminary experiments, and was found to depend on the form of the electrolytic cell, the concentration of the electrolyte, the presence of acid and other impurities, the presence or absence of a porous pot, and in the case of a rotating kathode on the speed of rotation. To prevent the formation of loose crystalline clusters it was also found necessary to regulate the current density according to the weight of the metal to be deposited. Empirical formulæ are given from which the limiting current density can be calculated.

The mean atomic weight for ten determinations was 63·563 ± 0·008, silver being taken as 107·88.

T. S. P.

2014. *Determination of Molecular Weights of Small Quantities of Gas or Vapour.* **M. Knudsen.** (Ann. d. Physik, 44. 4. pp. 525–536, June 4, 1914.)—Experiments are described which show that the molecular weight of a minute quantity of gas or vapour can be determined from its velocity of flow through a small aperture. In the case of air and oxygen the ratio was 1·057; the square of this ratio (= 1·117) agreed within 1 % with the ratio 1·105 of the densities.

T. M. L.

2015. *Properties of the Alkali Metals.* **L. Hackspill.** (Ann. Chim. Phys. 28. Ser. 8. pp. 613–696, 1913.)—The alkali metals rubidium, cæsium, and even potassium, can easily and rapidly be reduced in the pure state with almost theoretical yield by heating a mixture of the anhydrous chloride with metallic calcium in an exhausted tube of iron placed within an electric furnace. The author applies this method and determines the physical properties of the alkali metals, including sodium; he studies also the action of the metals on water. Taking the metals in the order of their atomic weights Na, K, Rb, Cs, the densities found at 0° were: 0·9723, 0·859, 1·525, 1·903; the coefficients of expansion of the solid metals: 0·000216, 0·00025, 0·00027, 0·00029 of the fused metals: 0·000274, 0·000288, 0·000338, 0·000345; the volume increases on fusion, in per cent.: 1·50, 2·42, 2·28, 2·32; the critical temperatures calculated from these latter data: 2025°, 1965°, 1857°, 1627° C. The thermal expansion was partly determined in benzene; but cæsium attacked benzene under formation—without visible generation of hydrogen—of a black substance C_6H_5Cs, which takes fire on exposure to air and explodes with CO_2; with chloroform it reacts violently, but carbon tetrachloride and pentane have no action. The vapour-pressure curves taken between 250° and 400° show that the vapour pressure increases at all temperatures in the order stated; the vapours seem to be monatomic, but the determinations of the density of the saturated vapours were not very concordant. The electric conductivity was measured against mercury on a double bridge, the metal being sealed into a cylinder of thin glass, 200 mm. long, from 8 to 12 mm. in diam.; four Pt-electrodes penetrated through the glass into the metal. According to E. Wagner (Ann. d. Physik, 33. p. 1484, 1910) the ratio of the conductivity of the solid metal to that of the liquid metal at its melting-point should be 3:2 for metals of the alkali group; the values found were: Na, 1·6; K, 1·5; Rb, 1·5; Cs, 1·7. All the resistances observed at temperatures from the melting-point down to the temperature of liquid air were lower than those of Juritz and Broniewski—this holds particularly for rubidium. The intensity of the action of water on the metals increased with the atomic weight of the metals and ceased at the following minimum temperatures of the metals in the order stated: −98°, −105°, −108°, and −116° C. H. B.

2016. *Rotatory Power of Tartaric Acid.* **G. Bruhat.** (Faraday Soc., Trans. 10. pp. 84–90, Aug., 1914. From the French.)—It is found impossible to account for the anomalous rotatory dispersion of tartaric acid either by the selective absorption of the acid for the violet or the ultra-violet or by the influence of the molecules of the solvent interposed between the active molecules. It is therefore assumed that there exist in solutions of tartaric acid two active compounds endowed with rotations of opposite signs and with different rotatory dispersions, the relative proportions of the two depending on the nature of the solvent, the concentration, and the temperature. Darmois has similarly explained the variability of the rotatory power of oils of turpentine and the anomalous rotatory dispersion shown by certain of these oils; the dispersion curves for mixtures of the two pinenes are, indeed, entirely analogous to those found for solutions of tartaric acid.

The author has extended Biot's study of the rotatory dispersions of transparent masses of superfused tartaric acid, precise measurements being made at temperatures ranging from 180–185° to 15°. The results show that the cause of the anomalous dispersion and its variation, both with the concentration and with the temperature, is the same in the case of solutions of tartaric acid as in that of the pure acid. The hypothesis of the formation of hydrates must, therefore, be rejected, and it seems that the second compound existing in the solutions or in the superfused mass can only be a complex formed by the grouping together of several molecules of the acid. Consideration of the results of osmotic and cryoscopic measurements on solutions of tartaric acid indicates that, in 25 % aqueous solutions or 2 % acetic acid solutions—which present marked anomaly in the rotatory dispersion, with a max. rotation in the blue or violet—the proportion of polymerised tartaric acid is very small and does not exceed 2–3 %. If this figure is accepted, the rotatory power of the complex will vary from about − 80° to − 200° between the C and F lines.

T. H. P.

2017. *High-temperature Research.* I. *Refractory Oxides in the Electron Vacuum Furnace.* **O. Ruff, H. Seiferheld**, and **J. Suda.** (Zeitschr. anorg. Chem. 82. pp. 373–400, 1913.)—The researches of 1910 have been resumed with the aid of a grant from the Verein Deutscher Ingenieure for the special object of finding oxides suitable as melting-point standards in electric carbon-tube furnaces. Even at considerably reduced pressure CO, H, at higher temperature further CN and hydrocarbons are generated in such furnaces, and these gases, though present in very small quantity, are capable of reacting chemically. The furnace walls adsorb air and moisture and replenish the gases. The gas pressure and the atmosphere are important; thus lime will not melt under very low pressure at 2450°, but melts at 2000° already in nitrogen at atmospheric pressure. The oxides are applied in cones, 1·5 cm. diam. 1 cm. high, or cylinders, 3 cm. high, placed on a layer of compressed carbon or graphite; the solid carbon does not appear to react with the oxide so long as there is no fusion of the oxide, which may, however, be started by a small impurity. Such reactions may cause the Leidenfrost phenomenon (oxides of Al, Mg, Ca) or reduction of the oxide; hence the carbon layer was sometimes replaced by a plate of dioxide of zirconium or magnesium, wetted and compressed. Temperature determinations were made with the aid of the Wanner pyrometer and based on the assumption, that the constant $C_2 = 14{,}600$, and the melting-point of Pt 1755°. The only oxide which is not reduced at ordinary pressure is magnesia, melting-point, above 2500°; but as it reacts with carbon, it is unsuitable for standardisation. At pressures below 30 mm. the oxides of beryllium (glucinum, melting-point 2525°) and calcium are also stable, but both volatilise. Zirconium dioxide, ZrO_2, has the highest observed melting-point, 2585°, but is partly converted into lower oxide. All these substances also make refractory vessels. Only alumina, Al_2O_3, melting-point 2010° ± 10° is recommendable for standardisation. The rare earths are unsuitable because they form carbides; the melting-points are: oxide of cerium, 1980°; thorium, about 2400°; niobium, Nb_2O_5 (not free from tantalum pentoxide), 1520°; lanthanum, 1840°. Titanium oxide, TiO_2, is reduced by the gases and turns, above 1000°, into the bluish oxide Ti_7O_{13}; slowly heated it begins to melt at 1800°, rapidly heated rutile at 1600° or 1700° only. Stannic oxide melts at 1625° and is at once reduced; the melting-point of Cr_2O_3 could not be determined.

H. B.

2018. *Synthesis of Borides in the Electric Vacuum Furnace.* **E. Wedekind.** (Ber. Deutsch. Chem. Gesell. 46. pp. 1198–1207, 1913.)—Mixtures of finely-powdered boron and the metal are highly compressed in the hy draulic pressof L. Weiss, and the electrodes thus obtained are fritted and used in the arc-furnace of L. Weiss modified by the author. With currents of 40 to 80 amps. at 70 to 80 volts borides are formed which melt and drop off or are deposited as powders on the asbestos tube sheathing the electrodes. In conjunction with C. Horst, O. Jochem, M. v. Wrangell, and H. Baumhauer the author thus prepares borides of zirconium Zr_3B_4, vanadium

VB, uranium UB_2, molybdenum, and tungsten WB_2. Most of these borides are hard (7) and resist acids and alkalies. In the case of Mo considerable difficulty was experienced, as the product would not drop off; the formula seemed rather to be Mo_3B than Mo_3B_4, the formula given by Tucker and Moody who described some of these borides in 1902. H. B.

2019. *Preparation of Pure Uranium.* **A. Roderburg.** (Zeitschr. anorg. Chem. 81. pp. 122–129, 1918.)—In spite of many experiments, uranium has not yet been obtained in the pure state. The author started from uranium tetrachloride and tetrafluoride. The tetrachloride is prepared by heating the ground oxide Ur_3O_8 with sugar to redness and then passing chlorine over the product in a porcelain boat, from which the chloride always takes up Si and Al, however. The brown metal obtained by using sodium as reducing agent in an iron vessel contains iron; vessels of nickel, silver, magnesia, and graphite are also attacked, nickel steel less so. The reduction of the tetrachloride which is more easily purified has to be effected by means of potassium, because the sodium fluoride cannot be washed out subsequently; but a suitable vessel which will prevent the escape of potassium vapours has not yet been found. H. B.

2020. *Optical Orientation of Cast Metals.* **K. Endell** and **H. Hanemann.** (Zeitschr. anorg. Chem. 88. pp. 267–274, Nov. 4, 1918.)—Some cast metals may be examined by the method of J. Königsberger by reflecting polarised light from the polished surface through a quartz plate and analyser. Two apparatus are used for this purpose; they may be attached to a large microscope; the manipulation of the apparatus is explained. Anisotropy is easily detected, and the method admits of distinguishing between enclosures in iron, *e.g.* Zn, Sb, Bi crystallise hexagonal-rhombohedric like ice, Sn (at least when normally cooled) tetragonal. The former crystals are orientated at right angles to the cooling surface; when the cooling metal is stirred, the orientation is irregular. Cementite Fe_3C in steel is anisotropic; so are iron phosphide and silicide, ferromanganese of 80 per cent., and sulphide enclosures, whilst silicate slag enclosures are isotropic and hence at once distinguishable. Cold-worked steel does not show anisotropy. H. B.

2021. *Zirconium.* II. **E. Wedekind.** (Liebig's Annal. d. Chemie, 395. pp. 149–194, 1918.)—The author, in conjunction with H. Kužel and also S. J. Lewis, finds that zirconium oxide cannot be reduced by Al or by Mg [see end of this Abstract], but can be reduced by mixing the oxide with very fine calcium shavings in an iron tube and heating until the reaction commences, the pressure being diminished to 0·5 or 0·1 mm. of mercury. The cold product is washed, under exclusion of air, with water, acetic acid, hydrochloric acid, acetone and dried, finally at 800° to 1000° in a vacuum, when it sinters to lumps which assume a brilliant mirror polish and contain 99·09 % of Zr and some oxygen. The attempt to remove the traces of oxygen by further heating with calcium in a nickel tube failed, the resulting metal containing only 97·5 % of Zr. The purer metal, pressed into rods and fused in a furnace of L. Weiss and E. Neumann, yielded globules of 98·5 %, less pure than those obtained by the just-mentioned investigators [see Abstract No. 1526 (1910)] The melting-point of zirconium which Wedekind and W. von Bolton had previously believed to be 2850°, lies probably very much lower, near 1850°, as Burgess found in 1908. The hydride ZrH_2—in which Zr would be divalent—and the nitride Zr_3N_2 do exist; the latter is a glistening powder of tombac colour, much more stable than the Zr itself, and conducts the current when compressed. The so-called crystalline Zr is really an aluminium zirconide; the graphitic Zr of Troost (said to be reduced with the aid of iron) is very doubtful. The amorphous Zr seems to be the only colloidal modification of the metal; by treatment with acids it passes into a hydrosol coagulating to a gel, the black amorphous Zr of Berzelius, which is, however, not an individual substance. Both the metallic and the amorphous Zr conduct the current after heating to 1000° in a vacuum; in air they burn; dilute acids do not attack them, chlorine does. Finally the author and J. Teletow state that the reduction of zirconium oxide by Mg succeeds to a certain extent at high temperature in a hydrogen atmosphere; but the repetition of the process yields a more and more pyrophoric substance, from which any oxide of the formula ZrO cannot be isolated. With the aid of calcium, the oxides of titanium, thorium, uranium, vanadium, tantalum can also be reduced. H. B.

2022. *Alloys of Molybdenum and Cobalt.* **U. Raydt** and **G. Tammann.** (Zeitschr. anorg. Chem. 83. pp. 246–252, Nov. 4, 1913.)—Cobalt cubes are purified by repeated fusing with broken porcelain in magnesia tubes, until a Co of 98 %, melting-point 1480°, is obtained. This is heated in magnesia tubes to 1800°; molybdenum (reduced after Biltz by Al from trioxide) is added. Up to 65 % Mo is dissolved by the Co. The freezing-point curve shows a eutectic point at 1335°, the eutectic containing 38 % of Mo. The curve then rises up to a break at 1484° corresponding to the compound MoCo which crystallises in long needles and does not form solid solutions; it is not magnetic. The solid solutions rich in Co are magnetic, and the transformation temperature falls from 1334° for Co to 750–790° for the saturated solution of 40 % of Co. There are no other definite compounds, but richer Mo alloys—impure with Al, however—can be prepared by the alumino-thermic process. H. B.

2023. *Ternary Alloys of Zinc-Silver-Lead.* **B. Bogitch.** (Comptes Rendus, 159. pp. 178–180, July 13, 1914.)—Earlier researches have shown that zinc and silver form six series of solid solutions and the compound Zn_3Ag_2; that silver and lead form a single eutectic containing 4 % Ag; and that zinc and lead are only partially miscible, forming two layers on cooling. The author has prepared about a score of the ternary alloys, of widely varying composition, and has studied the distribution of the three metals between the two layers. The results are plotted in the form of the well-known triangular diagram which shows that there are two fields: one, in which the three metals do not segregate from each other, and the other and larger field, in which the formation of two layers takes place. F. C. A. H. L.

2024. *Structure and Properties of Iron-Zinc Alloys.* **U. Raydt** and **G. Tammann.** (Zeitschr. anorg. Chem. 83. pp. 257–266, Nov. 4, 1913.)—By fusing together iron and zinc under pressure of 130 atmos. maximum the authors prepare a whole series of alloys, whilst so far 24 % of Fe had been the maximum attained; zinc dropped into liquid iron is rejected with explosive energy. A bomb and a furnace are used. The bomb forms a cylinder, 98 mm. high, 65 mm. in diam., built up of iron and carbon; the parts fit and are screwed into one another and are directly heated by the current. Hydrogen is admitted under pressure. The furnace is a magnesia cylinder, 60 mm. wide, surrounded by carbon rods 8 mm. in diam., which are so clamped by iron plates that the carbons appear to be bent back on themselves several times; this furnace only stood two meltings, the zinc vapours attacking the iron-zinc contacts. The iron and zinc are placed in tubes of a special porcelain. The fused alloys are analysed and examined microscopically; freezing-point curves of the iron-rich alloys have not been determined. Only two definite compounds $FeZn_7$ and $FeZn_3$ appear to exist. There is in addition a solid solution of zinc in iron containing saturated 80 % of Fe; this alloy is brittle and not malleable at ordinary temperature; a 90 % iron alloy is malleable when cold. The temperature of magnetic transformation falls as zinc is added to the iron, but remains constant at 650° for the range 80 % to 22 % of Fe. H. B.

2025. *Polymorphic Transformation of Thallium, Tin, Zinc, and Nickel.* **M. Werner.** (Zeitschr. anorg. Chem. 83. pp. 275–321, Nov. 4, 1913.)—Polymorphism is found in the group of the magnetic metals, in the group C, Si, Ti, Zr, Sn, and sporadically in Zn and Tl. The transformation of thallium is studied by means of cooling curves and in other ways at pressures up to 3000 kg./cm.². Within that range the temperature of transformation is gradually lowered, as the pressure is increased, from 226° to 220°. The heat of transformation calculated from the volume changes is 0·26 cal./gm.; Tammann's value, from the heat of fusion, is 0·27. Thallium wire 2 mm. in diam., 1·5 m. long, was prepared by forcing the metal through a nozzle; this wire is hard; by being heated above the transformation temperature it was changed into crystalline soft wire. The resistance of the wire was determined in an oil bath, the wire being soldered to Pt-leads from a bridge. The resistance falls sharply at the transformation temperature; that of the soft wire is 8 % smaller than that of the hard wire; the temperature coefficients of the two kinds of wire are different. As regards tin, there is a transformation under a pressure of 100 kg./cm.² at 168°, but it is not always distinct, nor is there any distinct discontinuity in the electric resistance at 161°, where the thermoelectric curve of a tin-nickel couple shows a break. The heat of transformation of tetragonal into rhombic tin is 0·02 cal./gm. The thermal effect observed in zinc by Benedicks and le Chatelier at 304° is confirmed, not that at 170° (Benedicks); there is no change in the elasticity at the latter temperature either, but the electric resistance and thermoelectric force show a change. In the case of nickel the resistance and thermoelectric force curves mark breaks at 355° to 365°, when the magnetic change occurs. There is no corresponding volume-change, however, and the heat of transformation, 0·013 cal./gm. is the same for soft as for hard wires.

The paper contains some p-T diagrams and discusses the recrystallisation of hardened metals. H. B.

2026. *Hypereutectic Alloys of Iron and Carbon.* **H. Hanemann.** (Zeitschr. anorg. Chem. 84. pp. 1–23, Nov. 18, 1913.)—Wittorf assumed the existence of the carbides Fe_3C, Fe_4C, FeC, and possibly FeC_2, but his estimates, especially of high temperatures by the aid of the optical pyrometer are questionable, as he melted his alloys in crucibles with the aid of the electric arc. The author fuses electrolytic iron and sugar charcoal and casts in iron chills, and concludes that the experiments prove the existence of one carbide only, cementite Fe_3C, and this only holds for the secondary, not for the primary cementite. When the bath is supersaturated with carbon, graphite rapidly crystallises, and graphite seems at all temperatures to be the stable form of carbon in the alloys. The so-called primary cementite can, at atmospheric pressure, only be obtained by excessively rapid quenching; it crystallises radially from the middle of an edge, suggesting its formation during cooling. As regards the equilibrium relations between cementite and liquid iron nothing but surmises can be offered. The paper refers in detail to the researches of Wittorf, Ruff, and others. H. B.

2027. *Specific Volumes of Nickel Steels.* **P. Chevenard.** (Comptes Rendus, 159. pp. 53–56, July 6, 1914.)—Since the densities of ferro-nickels at the ordinary temperatures are far from being simple functions of the composition the author has made a detailed study of the specific volumes of alloys of Fe and Ni at temperatures between − 195 and 750° C. The values at the absolute zero were then calculated by the aid of Nernst's theorem. The results are plotted in the form of Specific volume—Concentration curves which at the absolute zero consist of two straight lines intersecting at the ordinate of the compound Fe_2Ni. At 0° C. the alloys between about 20 and 50 % Ni show an anomalous behaviour owing to these alloys existing in the untransformed state. This branch of the curve is characterised by a maximum at about 36 % Ni. At 750° C. the curve is made up of three branches whose points of intersection lie on the ordinates of the compounds Fe_2Ni and $FeNi_2$. A study of the curves shows that the amplitude of the reversible anomaly is directly proportional to the amount of the compound Fe_2Ni contained in the alloy between the limits demanded by these two compounds. In the alloys containing less Ni, however, the amplitude of the transformation is proportional to the content of free iron. F. C. A. H. L.

2028. *A Study of Simple Overstrain.* **H. M. Howe.** (Mech. Eng. 34. pp. 150–151, Aug. 14, 1914. Abstract of paper read before the Amer. Soc. for Testing Materials, Atlantic City, June–July, 1914.)—Pursuing the general conceptions that the effects of overstrain may be either isotropic or anisotropic, two forms of anisotropy may be distinguished: (1) In which the overstrain strengthens the metal against later stress in the same direction, but weakens it against stress in the opposite direction; and (2) in which the metal is strengthened in all directions but to a degree which varies with the direction of the later stress, being greatest for stresses in the direction of the overstrain itself. Though the effects of the overstrain occurring in connection with repeated reversals of stress are clearly anisotropic there is much to indicate that the effects of a single overstrain are at least partially isotropic. Annealing appears to have more effect in removing the effects of simple overstrain than those of reversing overstrain. Further experiments are needed to show the true effects of annealing on the endurance. Simple overstrain followed by rest raises the tensile strength, the elastic limit and the proportionality limit, and these effects are repetitive and cumulative. Repeated reversals, however, do not appear to raise these properties to any appreciable extent. Indeed, there is evidence to show that reversing overstrain may efface the effect of prior simple overstrain. If this is true, it then follows that any rise of the tensile strength, etc., caused by prior overstrain is fictitious as regards the endurance of stress reversals and that the effective value of the fatigue is only that existing before the prior overstrain. Therefore engineering specifications for materials which are to be subjected to reversals of stress in use should ignore such elevation of the elastic limit by providing for its removal before testing. This can be effected by a short heating to 600° C. On the other hand, the results of Bairstow's work indicate that the elevation of the proportionality limit by cold-work is fictitious as regards stresses which, although varying within wide limits, yet remain constant in sign. This is opposed to common observations, of which the author cites several examples. It may be, however, that this persistence of the effects of overstrain during repetitions of stress both with and without change of sign is only temporary. Thus with moderately overstrained material Bairstow found that permanent set arose only after some 8000 stress reversals between

—8·8 and 18·8 tons per sq. in. It may be, therefore, that the very high overstrain existing in such materials as hard-drawn wire is practically permanent and will persist through an almost indefinite number of stress-cycles. No definite conclusions can be drawn as to whether repetitive stress beyond the primitive elastic limit does or does not efface the effects of prior overstrain. The whole question as to whether the strengthening is or is not fictitious for services implying indefinite repetitions of stress requires very careful study. A hard-drawn wire is stiff in every direction, showing that there is some transverse effect of the overstrain produced by a tensile stress. From the fact that overstrain in one direction lowers the proportionality limit in the opposite direction, it has been inferred that the overstrain is monotropic in the sense that it strengthens in its own direction but weakens in the opposite direction. This, however, has not been shown conclusively. Tensile overstrain certainly lowers the compressive proportionality immediately after the overstrain. This is no proof of monotropy, because at this time it will be found that the tensile proportionality limit is also very low, in fact it may have been reduced to zero. On heating, or even at the ordinary temperature, the lowered limit rises very rapidly with the time, and the author knows of no evidence to show that this is not equally true of the proportionality limit in compression. F. C. A. H. L.

2029. *Local Prevention of Case-hardening and Diffusion in Solids.* **L. Guillet** and **V. Bernard.** (Rev. de Métallurgie, 11. pp. 752–765, July, 1914.)—Three methods are in general use for the local prevention of case-hardening. (1) The part required soft is coated with refractory clay or cement. This method is never entirely successful on account of the difficulty of obtaining a material which possesses sufficient adhesive properties under the conditions and which is impermeable to the cementing gases at high temperatures. (2) The article is left too big in the parts required soft by an amount which is at least equal to the depth of the case, and then excess of material is machined away prior to quenching. In pieces of simple section this can also be done by covering the part with steel tubing prior to carbonising. After hardening the tube can be cracked away with a hammer. (3) A thin coating of metal is deposited on the part to be protected. To be effective the metal chosen should be solid at the temperature of carbonising, should be impermeable to the carbonising agencies under the conditions of working, should be readily obtained commercially, and should be capable of removal after the operations are completed. Only copper and nickel fulfil these conditions, and they may be deposited either electrolytically or by the Schoop process. Electro-deposited Ni was found to be permeable to CO at high temperatures with the result that the only effect was to produce a slight retarding of the rate of carbonisation. Simple immersion in solutions of copper salts gave unreliable results on account of the variations of the thickness and adherence of the layer. A thickness of 0·02 to 0·08 mm. of electro-deposited copper was found to give absolute protection at 1000° C. Similar results were obtained with deposits of copper obtained by the Schoop process. It appears therefore that copper deposition provides the practical solution, the choice as to whether the deposit is produced by the electrolytic or the Schoop process depending upon circumstances to a very large extent.

The authors have also made a study of the diffusion of metals into each other in the solid state. The phenomenon appears to be a very general one, and, providing that the contact is sufficiently good, can always occur when the two metals form solid solutions with each other. A knowledge of the constitution of the alloys gives, therefore, the information as to whether two metals will, under certain temperature conditions, diffuse into each other or not. F. C. A. H. L.

2030. *Granular Pearlite and Its Importance in the Heat-treatment of Steel.* **Hanemann** and **Morawe**. (Stahl u. Eisen, 33. pp. 1350–1355, 1913. Rev. de Métallurgie, 11. pp. 451-458, July, 1914.)—The origin of lamellar pearlite is regarded as being due to the solid solution becoming supersaturated with regard to one of the constituents (ferrite or cementite) during cooling. Corresponding to the position of each grain, a layer of cementite (in hypereutectoid steels) then separates and the solution becomes supersaturated with respect to ferrite which then forms another layer and again renders the solution supersaturated with cementite. The cycle of operations is repeated until the mass consists of a series of grains, in each of which the lamellæ are approximately parallel. Various writers have, however, described steels in which the cementite exists in the form of globules surrounded by the ferrite. This form has been called "granular pearlite" by the authors who have investigated the conditions under which it may be formed and the variation in the mechanical properties of the steel brought about by its presence. It is formed most easily in steels containing an excess of either ferrite or cementite over the eutectoid composition, and, in fact, in steels containing over 1·3 % carbon it forms the usual structure. Granular pearlite may be formed by cooling slowly through the Ar1 interval, by alternate heatings just above and below Ar1, by tempering a quenched steel at between 650° and 700° C., or by prolonged annealing of lamellar pearlite at temperatures slightly below Ac1. The conversion of the pearlite into the granular variety lowers the elastic limit and the tensile strength and increases the ductility. Bending tests show that the flexibility is also increased, a striking result being the extreme flexibility of a steel containing 1·56 % of carbon. The lamellar structure can easily be restored by heating at 800° C., followed by slow cooling, when the original properties are regenerated. The authors propose to call steels in which the pearlite has been converted into the granular condition, as "soft-annealed." Granular pearlite occurs in steels which have been cold-drawn or cold-rolled and also in damascened steel. F. C. A. H. L.

2031. *The Solidification of Metals.* **C. H. Desch**. (Inst. of Metals, Journ. 11. pp. 57–106, 1914. First Report of Beilby Prize Committee. Engineering, 97. pp. 437–440, March 27, and pp. 471–474, April 3, 1914.)—Summarises the present extent of our knowledge on a part of this subject.

2032. *Dielectric Constant and Solvent Power of a Liquid.* **W. E. S. Turner** and **C. C. Bissett**. (Chem. Soc., Journ. 105. pp. 947–952, April, 1914.)—Walden has found a relationship, $\epsilon\mu^{-1/3} = \text{const.}$, between the dielectric constant of the solvent and the "molecular solubility" μ of the salt tetraethylammonium iodide. Experimental tests have shown that no equality exists in the value of this expression for eight substituted ammonium salts in water and in chloroform, nor for lithium chloride in water and four alcohols, nor for tetrapropylammonium iodide in 15 solvents; nor is there any parallelism between the dielectric constant of the solvent and its solvent power for non-electrolytes such as *p*-nitrobenzyl chloride, trimethylamine and the common gases. On the whole, the dielectric constant of the solvent appears to exert an influence only when the solute is an electrolyte, and even then it is not the controlling factor in producing solution. T. M. L.

2033. *Fluctuations of Concentration in a Colloidal Emulsion.* **R. Costantin.** (Comptes Rendus, 158. pp. 1841–1848, May 11, 1914.)—The simple formula used by Svedberg does not represent the distribution of particles in a *concentrated* emulsion, but the formula of Smoluchowski relating the variations of concentration to the compressibility gives a satisfactory agreement.
T. M. L.

2034. *Osmotic Data in Relation to Progressive Hydration.* **W. R. Bousfield.** (Roy. Soc., Proc. Ser. A. 90. pp. 544–548, Aug. 1, 1914.)—Starting with Callendar's conception of osmotic pressure [Abstract No. 1720 (1908)], in which a "vapour-sieve piston" is used to deduce a relation between osmotic pressure and vapour pressure, the author deduces the relationship $\delta p/p = i/(h - n)$, where p is the vapour pressure, h the total water, n the combined water, and i the van't Hoff factor. T. M. L.

2035. *Influence of Temperature on the Density and Conductivity of Aqueous Salt Solutions.* II. **H. Clausen.** (Ann. d. Physik, 44. 7. pp. 1067–1076, July 17, 1914.)—Data are given for the densities of solutions of $RbNO_3$, RbCl, RbBr, RbI, Rb_2SO_4, CsCl at 6°, 18°, 30° C. These data are used to calculate the constants in the equation $\Delta_s = \Delta_t i + B_t(1 - i)$. [Compare Abstract No. 959 (1912).] T. M. L.

2036. *Extension of the Dilution Law to Concentrated Solutions.* **J. Kendall.** Amer. Chem. Soc., Journ. 36. pp. 1069–1088, June, 1914.)—Ostwald's "Dilution Law" gives $c_i^2/c_u = K$ where c_i is the concentration of the ionised and c_u the concentration of the un-ionised part of the salt. If it be assumed that ionisation is brought about by the mass-action of the solvent, this equation becomes $c_i^2/c_u = K . c_s$. For dilute solutions c_s is constant, but it varies at higher concentrations. If a correction be made for this and for the changing viscosity of the liquid, the dilution law can be extended to N/2 in the case of the fatty acids and ammonia, which otherwise show marked deviations at N/10. T. M. L.

2037. *Fluidity as a Function of Volume, Temperature, and Pressure.* **E. C. Bingham.** (Amer. Chem. Soc., Journ. 36. pp. 1393–1408, July, 1914.)—Fluidity is proportional to the "free volume" of Batschinski, in pure liquids and mixtures, and in suspensions of solids in liquids, *i.e.* $v = w + c\phi$, or $\phi = 1/c(v - w)$; where v is the volume, w is the limiting volume toward which the volume approaches as the fluidity approaches zero, and $v - w$ is the free volume. An equation resembling that of van der Waals may be used, therefore, to reproduce the fluidity data as a function of the temperature and pressure. Such an equation breaks down when applied to gases, the fluidity of a gas being invariably smaller than would be expected from the modified van der Waals' equation. Viscous resistance in gases originates largely in the diffusion of the moving material, the energy of which is converted by repeated collisions into disordered motion. This motion is called "diffusional viscosity." In viscous liquids the resistance to flow caused by diffusion is negligible. The resistance is due mainly to the collisions of molecules of one layer with those of an adjacent layer moving at a slightly lower velocity. This transfer of momentum without a transfer of matter is called "collisional viscosity." The viscosity of a gas or liquid is the sum of the diffusional and collisional viscosities. We thus obtain an approximate formula $\phi = (v - w)/[A + BT(v - w)]$ which can be used to reproduce the observed fluidities of CO_2 with considerable fidelity. The apparent viscosity of a gas as it becomes rarefied, decreases rapidly, in accord with the theory that slipping does not occur even in rarefied gases. In gases at ordinary temperatures and pressures, the fluidity decreases as the temperature is raised, but is nearly independent of the pressure, indicating that diffusional viscosity is of preponderating importance. At very low temperatures, however, the fluidity is inversely proportional to the pressure. At very high temperatures the fluidity may increase with the pressure. The fluidity of practically all liquids increases with rising temperature and decreased pressure, probably on account of the decreased number of collisions. Sulphur and water are exceptional on account of association. In nearly all liquids an increase in the molecular weight causes an increase in the temperature required to produce a given fluidity; in homologous series this increase is proportional to the increase in molecular weight. Formic and acetic acids are exceptions on account of their association. T. M. L.

2038. *Ionisation and the Law of Mass Action.* III. *Utilisation of the Osmotic Data and a New Dilution Law.* **W. R. Bousfield.** (Chem. Soc., Journ. 105. pp. 1809–1828, July, 1914.)—The two quantities, a = coefficient of ionisation, n = combined water, appear in such a way that the three equations furnished by the osmotic data are no better than one; neither a nor n can therefore be determined except when the hydration h is so great that n can be neglected. Under these conditions all the mass-action equations (except Ostwald's) become identical [see Part I, Abstract No. 1105 (1913)]. The equation now proposed to express the dilution law is $a^2/1-a=K(h-n)^{1/n}$. Unlike former equations it contains a term n which must be found experimentally, but it has the advantage that it may be deduced from the law of mass-action, by assuming that the final stage in the process of ionisation is the attack of a single molecule of dihydrol, H_4O_2, on two molecules of the solute. Neither a nor n can be deduced from the conductivity, as the ionic mobilities are quite unknown except in dilute solutions, but data may be obtained from osmotic measurements, and especially from the vapour pressures. In the special case of lithium chloride, the evidence indicates that $n = 38\,a - 14$, so that at infinite dilution $n = 24$, where a determination by another method has given $n = 21$. In a saturated solution at 18° there are only 8 molecules of water, and the combined water n is probably 1·4, whence $a = 0·4$, *i.e.* there are 0·6 mols. LiCl, H_2O (not ionised) and 0·4 mols. LiCl, $2H_2O$ (ionised). T. M. L.

2039. *Variation of Electric Potential across a Semipermeable Membrane.* **F. G. Donnan** and **G. M. Green.** (Roy. Soc., Proc. Ser. A. 90. pp. 450–455, July 20, 1914.)—Experiments were made to test whether the p.d. between two solutions of an electrolyte, separated by a membrane impermeable to it but permeable to the solvent, agreed with those calculated from a formula already given. Potassium ferrocyanide was used with copper ferrocyanide membranes. In all cases in which one solution was normal, large deviations (28 to 29%) were found, probably because the transport numbers and degree of ionisation are so uncertain. Using solutions from N/10 downwards, the deviations ranged from 2% for N/10 against N/20 to 14% for N/10 against N/200; this increasing error seems to be due to growing errors in the calculation of the "diffusion potential" when no membrane is present, the p.d. introduced by the membrane being correctly represented by the formula $\pi_2 - \pi_1 = RT/F \,.\, \log\,(a_1/a_2)$, where a_1 and a_2 are the "activities" of the potassium ion in the two solutions. T. M. L.

2040. *Diffusion and Membrane Potentials.* **E. B. R. Prideaux.** (Faraday Soc., Trans. 10. pp. 160–165; Discussion, pp. 165–166, Aug., 1914.)—The author has measured the diffusion e.m.f. of the combination: Hg, HgCl, N-KCl | NaB(C_1) | NaB(C_2) | N-KCl, HgCl, Hg, where NaB(C_1), and NaB(C_2) represent solutions of sodium benzoate of the concentrations C_1 and C_2. In one set of experiments the solutions were connected by means of a siphon tube, whereas in the other they were separated by a parchment membrane, which was held in position by a suitable arrangement. The e.m.f.'s given by the ordinary diffusion potential were found to be represented by the straight line: E (millivolts) $= 1 + 18{\cdot}5 \log (a_1C_1/a_2C_2)$, where a_1 and a_2 represent the dissociation of sodium benzoate in the respective solutions. Since the diffusion potential is also given by the equation $E = 0{\cdot}058(1 - 2n_A) \log (a_1C_1/a_2C_2)$, the transport number of the anion (n_A) can be calculated, and is found to be 0·888, in good agreement with the value calculated from the ionic mobilities, namely, 0·388. When the two solutions were separated by a parchment membrane, the diffusion potential was represented by the straight line: $E = 4{\cdot}58 + 24{\cdot}8 \log (a_1C_1/a_2C_2)$, from which it follows that $n_A = 0{\cdot}286$. The transport number of the anion in the membrane is thus less than three-quarters of its value in the free solution. It is remarkable that the straight line does not, as in the case of diffusion potentials, pass almost through the origin, but intercepts an ordinate of 4·5 millivolts. The author is unable to suggest an explanation of this. T. S. P.

2041. *Electrometallurgy of Aluminium.* **P. P. Fedotieff** and **W. Iljinsky.** (Zeitschr. anorg. Chem. 80. pp. 118–154, 1918.)—The authors study the electrolysis of aluminium in fused cryolite as technically applied with special regard to the system AlF_3–NaF. The statements as to the melting-point of cryolite are contradictory because the cryolite is impure and contains in particular silica, in appearance like the cryolite. Aluminium fluoride cannot be deprived of its water by heating, because hydrolysis into HF and Al_2O_3 sets in; but the salt can be sublimed yielding large crystals when not cooled too quickly; the anhydrous salt is not attacked by concentrated sulphuric acid. The pure cryolite 8NaF. AlF_3 melts at 1000° C.; there is also a compound 5NaF. AlF_3 the (mineral chiolite) which does not melt, but is transformed into cryolite and a liquid at 725°; at 565° monoclinic cryolite passes into regular cryolite, the eutectic points at 685° and 880° correspond to 14 and 46·4 mols. per cent. of AlF_3. Cryolite and alumina form solid solutions, but alumina is more soluble in the eutectic NaF–Na_3AlF_6 than in cryolite, with the curves passing through a minimum; alumina is not soluble in NaF, and its solubility in the cryolite is diminished by the addition of AlF_3. The continued reduction of Al from the bath requires a p.d. of 2·1 or 2·2 volts. But gas is generated at 1·8 volts already, and the formation of metallic fog (emulsification) follows. Owing to this emulsification and also to the formation of the carbide Al_4C_3 the yield of Al does not exceed 70 %. The carbide is formed independent of the current in the fused mass at the anode when the temperature is between 1000° and 1100°. When the bath is too rich in alumina near the anode, the potential rises, and sparks may be observed; the bath should be stirred, and rotating anodes might answer. The destruction of the anodes is accelerated by the addition of NaF to the bath. The melting-point of the salts can be lowered by using chiolite instead of cryolite and keeping the alumina-content down to 7·5 %. The melting-point is also lowered by the addition of CaF_2 to the bath; but the bath is then denser and does not dissolve alumina so readily; a eutectic of the two fluorides, Ca and Al, is formed at 815 to 820° and contains 87·5 mols. per cent. of AlF_3. H. B.